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WORLD NAVAL REVIEW

2021

Edited by
Conrad
Waters

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Editor
CONRAD WATERS

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Frontispiece: The crew of the new Japanese submarine *Oryu* are seen wearing protective masks as a precaution against the COVID-19 pandemic in a photograph probably taken at the time of her maiden arrival at Kure Naval Base on 7 April 2020, where she joined Submarine Squadron 3 of the JMSDF's 1st Submarine Flotilla. Delivered on 5 March 2020, *Oryu* is the tenth member of the *Soryu* class. Unlike her sisters she is equipped with lithium-ion batteries, making her the first submarine in the world to utilise this technology. *(JMSDF)*

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Note on Tables: Tables are provided to give a broad indication of fleet sizes and other key information but should be regarded only as a general guide. For example, many published sources differ significantly on the principal particulars of ships, whilst even governmental information can be subject to contradiction. In general terms, the data contained in these tables is based on official information updated as of June 2020, supplemented by reference to a wide range of secondary and corporate sources, such as shipbuilder websites.

1 OVERVIEW

INTRODUCTION

Author:
Conrad Waters

'Sent in this foul clime to languish, Think what thousands fell in vain; Wasted with disease and anguish, Not in glorious battle slain.' So wrote the English poet and politician Richard Glover (1712–85) in his popular ballad 'Admiral Hosier's Ghost', a polemic on an ill-fated Royal Navy expedition to the Caribbean in which Hosier and thousands of his command were doomed to death from disease as a result of governmental ineptitude. The circumstances of the current COVID-19 pandemic that is afflicting all our lives are clearly very different from those that befell Admiral Hosier's mission. Nevertheless, it is difficult for any review of the past year – irrespective of its subject matter – not to be overshadowed by a global disaster that has been exacerbated both by a lack of preparedness and by political miscalculation. A grim milestone was reached by early June 2020 when it was reported the virus had claimed more American lives than had died in all that country's wars since 1945.[1]

The full ramifications of COVID-19 on future naval developments are difficult to quantify at a time when the pandemic has yet to run its course. However, three observations seem pertinent.

1. Flexibility: The ability of navies around the world to respond flexibly and effectively to an unexpected emergency has again been demonstrated. In the United States, the hospital ships *Comfort* (T-AH-20) and *Mercy* (T-AH-19) were deployed, respectively, to New York and Los Angeles to bolster local medical services. Although the number of patients treated was small, the additional capacity they brought was of significant value at a time of fears that normal hospital facilities might be overwhelmed.

Specialist naval assets – particularly those with logistical and medical support functions – have been particularly valuable providing assistance where local medical infrastructure's ability to handle a crisis is limited. In France, the amphibious assault ship *Tonnerre* was used to evacuate COVID-19 patients from Corsica's overstretched hospitals for treatment on the mainland in late March. Subsequently, her sisters *Dixmude* and *Mistral* were dispatched to provide additional resources for France's overseas territories in the Indian Ocean and Caribbean as part of the French military's broader Operation '*Résilience*'. The United Kingdom and the Netherlands also reinforced their assets in the Caribbean with the deployment of the casualty receiving ship *Argus* and the joint support ship *Karel Doorman.* The three countries have agreed to coordinate their military response to the crisis in the region.

2. Vulnerability: Whilst navies have brought valuable skills to combatting the COVID-19 crisis, the pandemic has also revealed their vulnerability to the virus. It seems a full picture is unlikely ever to be available given obvious security considerations. However, some significant outbreaks have been widely reported, notably on the aircraft carriers *Theodore Roosevelt* (CVN-71) and *Charles de Gaulle.* As many as 60 percent of the latter's crew ultimately fell ill after sailors started exhibiting symptoms whilst the ship was operating in the North Atlantic. Fortunately all eventually recovered. In general terms, it seems that the cramped berthing conditions typically found in older ships have been more conducive to the virus' spread than the more spacious cabins specified in recent surface designs. This would suggest a particular vulnerability in submarines, with potentially worrying implications for submarine-based strategic deterrents.[2]

It is noteworthy that many navies have proved successful at adapting their operating procedures to respond to the new circumstances. For example, the British Royal Navy quickly introduced measures involving the quarantining of the entire crew on

The British Royal Fleet Auxiliary's casualty receiving ship *Argus* is one of a number of assets European countries have deployed to the Caribbean to reinforce local medical facilities in case of need during the COVID-19 pandemic. This picture was taken in the spring of 2020 and shows her crew marking out the numbers 75 on her flight deck to commemorate the 75th anniversary of the end of the Second World War in Europe. *(Crown Copyright 2020)*

board its submarines prior to deployment.[3] Similar measures enabled the carrier *Queen Elizabeth* to continue working up towards operational readiness during the height of the pandemic in the United Kingdom. However, challenges remain. One potential problem area relates to the backlog of deferred maintenance and construction that has built up whilst shipyards and support facilities have been impacted by coronavirus-related lockdowns. The fact that the Chinese shipbuilding hub of Wuhan was the initial epicentre of the COVID-19 crisis clearly illustrates this problem. Perhaps the highest-profile casualty has been delivery of India's already long-delayed indigenous aircraft carrier *Vikrant,* which reportedly faces a minimum six-month delay to commencement of her basin trials. In mid-June 2020, the US Navy went so far as to call up over 1,600 reservists to help combat delays to aircraft carrier and submarine refurbishment at its already struggling publicly-owned shipyards.

3. Uncertainty: In the longer term, the current pandemic's impact on the world's economies seems likely to have major consequences for government finances and, hence, defence and naval procurement. It also seems probable that public demands for greater investment in public healthcare service resilience will prove irresistible, leaving defence establishments globally fighting for a smaller slice of a diminished cake. Some governments – most prominently India and the Republic of Korea – have already announced material short-term reductions to defence spending to help fund their COVID-19 response. The implications for harder-hit economies, such as those of the United States and much of Europe, may well be more severe. It is, however, still far too early to assess what the practical consequences of this more difficult backdrop will be, particularly as the crisis has done little to diminish international tensions.

DEFENCE BUDGETS AND PLANS

For the time being, the current state of world defence spending is best illustrated by the annual assessment provided by the independent Stockholm International Peace Research Institute (SIPRI). This was last published in April 2020. Their calculations suggest total global military expenditure rose to US $1,917bn in 2019, a real-terms increase of 3.6 percent over the previous year and the largest annual growth in spending since 2010. However, defence's share of GDP or global economic output – the so-called world military burden – was little changed at 2.2 percent and only just above the decade lows since in 2014 and 2018. Table 1.1 provides details of the world's ten highest spending nations.

The United States continues to have by far the largest military budget in the world, with the largesse of the early years of the Trump administration reflected in the material c. 5 percent uplift in spending seen in 2019. However, its military expenditure remains 15 percent below the peak achieved in 2010 and is now set to plateau as the US Department of Defense budget starts to be more tightly controlled. The table is notable in that two Asian countries – China and India – now occupy the other top three spending places for the first time. This followed a significant rise in India's defence budget and a marked fall in defence allocations by former third-placed Saudi Arabia. SIPRI's commentary accompanying the release of the 2019 data noted that defence spending in Asia and Oceania now accounts for 27 percent of the global total following a real-terms increase of just over a half in the last ten years. In spite of this, the region's military burden – the percentage of GDP or economic output allocated to defence spending – remains relatively well-controlled. For example, China's defence spending has increased by around 85 percent to an estimated US$261bn over the past decade but it still devotes less than 2 percent of its GDP to its military establishment.

These statistics illustrate the trend referenced in several previous editions of *Seaforth World Naval*

Table 1.1: COUNTRIES WITH HIGH NATIONAL DEFENCE EXPENDITURES 2019

RANK 2019	(2018)	COUNTRY	TOTAL US$BN 2019[1]	SHARE OF GDP 2019	WORLD SHARE 2019	TOTAL US$BN 2018[1]	REAL CHANGE 2018–2019	REAL CHANGE 2010–2019[2]
1	(1)	United States	732	3.4%	38%	682	5.3%	-15%
2	(2)	China	[261]	[1.9%]	[14%]	[253]	[5.1%]	[85%]
3	(4)	India	71.1	2.4%	3.7%	66.3	6.8%	37%
4	(5)	Russia	65.1	3.9%	3.4%	61.4	4.5%	30%
5	(3)	Saudi Arabia	[61.9]	[8.0%]	[3.2%]	[74.4]	[-16.0%]	[14%]
6	(6)	France	50.1	1.9%	2.6%	51.4	1.6%	3.5%
7	(9)	Germany	49.3	1.3%	2.6%	46.5	10.0%	15%
8	(7)	United Kingdom	48.7	1.7%	2.5%	49.9	0.0%	-15%
9	(8)	Japan	47.6	0.9%	2.5%	46.6	-0.1%	2%
10	(10)	South Korea	43.9	2.7%	2.3%	43.1	7.5%	36%
-	(-)	**World Total**	**1.917**	**2.2%**	**100%**	**1,849**	**3.6%**	**7.2%**

Information from the Stockholm International Peace Research Institute (SIPRI) – https://www.sipri.org/databases/milex The SIPRI Military Expenditure Database contains data on countries over the period 1949-2019.

Notes:

1. US$ totals for 2019 and 2018 are based on then current (i.e. non-inflation adjusted) prices and exchange rates for the years in question. Exchange rate movements, in particular, can therefore result in significant movements in the US$ figures and explain apparent discrepancies in the table. SIPRI also adjust previous years' calculations when more accurate data becomes available – this has resulted in several significant differences from the 2018 total figures contained in last year's *Seaforth World Naval Review*. Notably, spending for France was revised down significantly by disaggregating non-military related activities carried out by the Gendarmerie from total defence expenditure.

2. The 'real' change figure is based on constant (2018-based) US$ figures.

3. Figures in brackets are SIPRI estimates.

Review of the steady shift in both economic and military power towards the Asian countries. The 2019 data was also noteworthy in that no Western European country now falls within the top five spenders following a reclassification of data that saw the deletion of much of the budget for France's paramilitary Gendarmerie from the SIPRI figures. There are, however, some interesting variations in Western European trends. For example, Germany's defence spending has increased sharply in the face of pressure to increase its share of the NATO burden against the backdrop of renewed East-West tension. Its spending in 2019 was at the highest level since 1993, seeing it jump over the United Kingdom to seventh in the league table in the process.[4]

FLEET REVIEWS

The 'snapshot' of global naval power provided by the summary of major fleet strengths provided in Table 1.2 is broadly reflective of the financial fundamentals referred to above. The US Navy continues to be the world's dominant 'blue water' fleet, operating a balance of highly sophisticated assets that provide much greater potency than raw numbers can convey. However, growing overall fleet numbers is becoming a major priority as the United States increasingly embraces a 'distributed maritime operations' concept to respond to the potential for all-out conflict in the Asia-Pacific region with an emergent China. This essentially involves dispersing warfighting capability across a wide range of ships and other assets that are linked together by technology to achieve maritime superiority. The concept inevitably places more emphasis on smaller, cheaper ships that can be afforded in greater numbers than more expensive 'capital ships' such as aircraft carriers and large surface combatants. These smaller, cheaper warships will include an unmanned surface vessel component. A major Integrated Force Structure Assessment (INFSA) – involving both the US Navy and US Marine Corps – is currently underway to determine the appropriate future force mix in what might be a once-in-a-generation change.[5] In the meantime, the arrival of growing numbers of small combatants in the form of Littoral Combat Ships – ultimately to be followed by a new frigate class – is already starting to shift overall fleet architecture.

Perhaps ironically, there are some signs that China's People's Liberation Army Navy (PLAN) is pursuing a strategy – involving substantial investments in carriers and larger surface combatants – that runs directly contrary to that being pursued by its American rival. The last 12 months have seen the formal commissioning of the PLAN's first indigenous aircraft carrier – the Type 002 *Shandong* – on 17 December 2019. This was followed by that of the large Type 055 destroyer *Nanchang* on 12 January 2020. At least seven more Type 055 destroyers as well as a new, larger aircraft carrier and two amphibious assault ships are under construction. In the meantime, programmes for smaller vessels such as Type 054A frigates and Type 056A corvettes are seemingly winding down without any evidence of

TABLE 1.2: MAJOR FLEET STRENGTHS 2019-2020[1]

REGION	THE AMERICAS				EUROPE & RUSSIA										ASIA								IND. OCEAN	
COUNTRY	USA		BRAZIL		UK		FRANCE		ITALY		SPAIN		RUSSIA		CHINA		JAPAN		KOREA(S)		AUSTRALIA		INDIA	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Carriers & Amphibious																								
CV/CVN	11	11	–	–	1	2	1	1	1	1	–	–	1	1	1	2	–	–	–	–	–	–	1	1
CVS/CVH	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	4	4	–	–	–	–	–	–
LHA/LHD/LPH	9	10	1	1	–	–	3	3	–	–	1	1	–	–	–	–	–	–	1	1	2	2	–	–
LPD/LSD	23	23	1	1	5	5	–	–	3	3	2	2	–	–	6	6	3	3	–	–	1	1	1	1
Submarines																								
SSBN	14	14	–	–	4	4	4	4	–	–	–	–	11	12	5	7	–	–	–	–	–	–	1	1
SSN/SSGN	55	56	–	–	6	7	6	5	–	–	–	–	25	25	9	9	–	–	–	–	–	–	1	1
SSK	–	–	5	5	–	–	–	–	8	8	3	2	20	20	50	50	19	20	17	18	6	6	14	14
Surface Combatants																								
BB/BC	–	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–
CG/DDG/FFG	91	92	7	7	19	19	16	15	16	16	11	11	30	30	70	70	38	38	25	23	11	11	23	23
DD/FGS/FS	18	22	2	2	–	–	13	13	1	–	–	–	40	40	50	60	6	6	13	12	–	–	11	12
FAC[2]	–	–	–	–	–	–	–	–	–	–	–	–	35	35	75	75	6	6	18	18	–	–	8	8
Other (Selected)																								
MCMV	11	11	4	4	13	13	13	13	10	10	6	6	40	40	25	25	22	21	9	9	4	4	–	–
AO/AOR/AFS	29	29	1	1	9	9	3	3	3	3	2	2	20	20	13	14	5	5	3	3	2	1	4	4

Notes

1 Numbers are based on official sources, where available, supplemented by news reports, published intelligence data and other 'open sources' as appropriate. Given significant variations in available data, numbers should be regarded as indicative, particularly with respect to Russia, China and minor warship categories. There is also a degree of subjectivity with respect to warship classifications given varying national classifications and this can also lead to inconsistency.

2 FAC numbers relate to ships fitted with or for surface-to-surface missiles.

immediate progression to follow-on designs. Whilst it would be unwise to read too much into these developments, they do seemingly offer the intriguing prospect of the world's two leading navies converging more closely in structure over time.

Although public attention inevitably continues to focus on developments in the larger navies, other fleets are also experiencing significant change in the light of revised operational priorities. In this year's edition, Dieter Stockfisch turns his attention to the Swedish Navy, which is embarking on a reorientation back towards territorial defence as East-West tensions re-emerge. Meanwhile Mrityunjoy Mazumdar continues his assessment of some of the world's lesser-known fleets with an examination of the Nigerian Navy. Although Nigeria's fleet is free from any meaningful threat from a state-based rival, it faces immense challenges attempting to overcome the depredations of piracy and other organised crime that have seen the Gulf of Guinea overtake the Horn of Africa as a global hotspot for attacks on maritime trade.

SIGNIFICANT SHIPS

One country that has proved remarkably successful in achieving a high level of security in a complex maritime environment is Singapore. Its navy's increasing use of technologically-driven solutions to achieve operational results are demonstrated by the new *Independence* class littoral mission vessels, which are described in detail by Guy Toremans. The fruit of considerable scientific research, the *Independence* design combines multi-mission modularity with advanced sense-making and decision support functions to allow a wider range of missions to be performed by a smaller crew.

Meanwhile, a major question that is likely to be answered when the conclusions of the US Navy's INFSA are released is the future composition of its amphibious forces. For decades, these have been focused on three-ship amphibious ready groups (ARGs) headed by a large, through-deck amphibious assault ship. First-time *Seaforth World Naval Review* contributor George Galdorisi joins forces with 'old hand' Scott Truver to assess the unique capabilities of these vessels in an examination of *America* (LHA-6), the latest iteration of the type. Whilst it seems the days of large-scale amphibious beach assaults are now relegated to the history books, *America* and her sisters provide substantial aviation facilities that remain relevant in an age of fast-moving, distributed operations.

One design that has undoubtedly stood the test of

The Chinese Type 052D destroyer *Yinchuan* refuels from the Type 903 comprehensive supply ship *Weishanhu* during operations in the Gulf of Aden in February 2020. China's People's Liberation Army Navy continues to develop 'blue water' naval capabilities in seeming emulation of its American rival. *(Chen Wencai and Wen Zaifei/China Military Online)*

The Swedish submarine *Halland* pictured during the US Navy-led BALTOPS 2016 exercise. Sweden is having to re-orientate its armed forces back towards territorial defence in the face of renewed East-West tensions but faces a difficult balancing act maintaining a policy of military neutrality whilst increasing collaboration with friendly nations. *(US Navy)*

The British Royal Navy Type 23 'Duke' class frigates have proved to be an enduring design. *Sutherland* – seen here on the Clyde in October 2019 – is expected to remain in service until the early 2030s, some 50 years after the design was first conceived. *(Michael Leek)*

time is the British Royal Navy's Type 23 'Duke' class frigate. The type celebrated the thirtieth anniversary of lead ship *Norfolk*'s entry into service on 1 June 2020. Younger ships are set to remain operational for a further decade and more. The author describes how what was originally a highly specialised design intended for North Atlantic submarine hunting has metamorphosed into a general-purpose combatant suitable for global deployment.

TECHNOLOGICAL DEVELOPMENTS

Our final section on technological developments encompasses a wide variety of topics. David Hobbs' regular review of world naval aviation includes an assessment of various aspects of naval air training, using United States Navy and Royal Navy practice as examples. Norman Friedman examines the application of seaborne stealth in all its forms, paying particular attention to the extreme approach adopted by the US Navy's *Zumwalt* (DDG-1000) to demonstrate the resulting trade-offs and limitations. By way of contrast, Richard Scott's evaluation of the American Standard series of missiles demonstrates how an evolutionary process tracing its origins to the 1940s has successfully provided the US Navy and its allies with a range of leading-edge capabilities.

This year's review concludes with an assessment of the distributed maritime operations (DMO) concept that is driving both the INFSA review and wider US Navy thinking. Another new and distinguished contributor, Kevin Eyer, traces the technological and strategic drivers behind the ambition. Equally importantly, he also highlights some of the remaining challenges that need to be overcome if the approach is to yield its full potential.

SUMMARY

After more than a decade of reviewing maritime developments for *Seaforth World Naval Review*, the editor finds it hard not to see the last year as something of a watershed. The renewed era of great-power rivalry heralded by China's economic rise and emphasised in recent US strategic documents is resulting in a new focus on naval force structures and

Naval air training takes many forms, including the provision of air threat simulation for both warships and aircraft. Much of this role currently falls to the BAE Systems Hawk jets of Fleet Air Arm's 736 NAS. Here, a Hawk T1 is seen whilst operating with the Fleet Requirements & Air Direction Unit (FRADU), the squadron's predecessor. *(Michael Leek)*

priorities that will have consequences the world over. The seeming willingness of the American defence establishment to re-examine the merits of long-established concepts such as the primacy of the carrier strike group against those of distributed force architectures reliant on new technologies and embracing a significant unmanned element is particularly noteworthy. A key driver appears to be an appreciation that 'business as usual' is no longer an option as economic power continues to transition towards Asia. Whilst any final assessment is premature, it is not unlikely that the current pandemic will only serve to accelerate this reality.

The new Japanese Aegis-equipped destroyer *Maya* seen at the time of her delivery in March 2020. Derived from the US Navy's *Arleigh Burke* class, she exhibits greater attention to radar-cross section reduction than her American predecessors and utilises an acoustically stealthy COGLAG propulsion system. Her armament includes the latest iterations of the highly successful series of Standard surface-to-air missiles. *(JMSDF)*

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As always, the editor will conclude by thanking his wife Susan – this year joined by our younger daughter Imogen in 'lockdown' – for her customary patience and good humour in proof reading the initial drafts of my text. He wishes all readers good health in these difficult times and looks forward to further comments and criticisms, which should be directed for my attention to: info@seaforthpublishing.com.

Conrad Waters, Editor
30 June 2020

Notes

1. This figure was cited by several newspapers early in June 2020, for example, in Max Boot's article 'We are living in a bipartisan state of denial about the coronavirus' that appeared on *The Washington Post*'s website – washingtonpost.com – on 10 June 2020. A particularly sad feature of the crisis has been the number of veterans who survived the Second World War and other conflicts only to succumb to the virus.

2. An interesting assessment of the potential vulnerability of the United Kingdom's strategic deterrent to the COVID-19 virus was provided by Harvard University's David Arceneaux in an article 'COVID-19 and British Nuclear Deterrence' posted to the *War on the Rocks* website – warontherocks.com – on 24 April 2020.

3. See James Heappey, Submarines: Coronavirus, *UK Parliament: Written Answer*, 11 May 2020 HC 42123, '... Measures have been introduced prior to sailing which involve the whole ship's company quarantining onboard the submarine. In addition, personnel who are, or whose households are, symptomatic will be isolated before embarking, in accordance with [Public Health England] self-isolation guidelines.'

4. See Nan Tian, Alexandra Kuimova, Diego Lopes Da Silva, Pieter D Wezeman & Siemon T Wezeman, *SIPRI Fact Sheet: Trends in World Military Expenditure, 2019* (Stockholm: SIPRI, 2020). Interestingly, SIPRI's estimate of United Kingdom military expenditure was US$11.2bn lower than the figure that the UK reported to NATO. SIPRI stated that its own figure was based on public expenditure data published by the British Ministry of Defence and suggested that part of the difference might be accounted for by (i) military pension payments of c. US$3–4bn and (ii) contributions to UN peacekeeping operations not covered by the Ministry of Defence budget. However, these additional expenditure items do not fully bridge the gap, leaving questions remaining about what exactly was included in the NATO expenditure figure. The discrepancy is significant in the context of allegations that the United Kingdom has effectively 'cooked the books' to remain compliant with NATO guidance that members should spend at least 2 percent of GDP on defence.

5. Analysis of these plans and the issues surrounding them can be found in Ronald O' Rourke's *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress RL32665* (Washington DC: Congressional Research Service, 2020). Like many of Mr O'Rourke's other periodically-updated reports referenced in this and previous editions of *Seaforth World Naval Review*, this report has been posted as a public service on the Federation of American Scientist's website at: fas.org/sgp/crs/weapons/

2.1 REGIONAL REVIEW

NORTH AND SOUTH AMERICA

Author:
Conrad Waters

The last year has seen a turning point for the US military as the generous funding that marked the Trump administration's early years has finally hit the buffers. The reason is a political compromise hammered out in the course of 2019 to resolve the ongoing impact on government spending of the caps that were first imposed by the 2011 Budget Control Act to help control the large US deficit. From a defence perspective, the agreement permitted total spending of no more than US$738bn in FY2020 and US$740.5bn in FY2021. These numbers compare relatively favourably with the US$716bn agreed in FY2019 but are materially less than the US$750bn the administration initially proposed to spend in FY2020. Although the regime of financial controls expires in FY2021, future prospects for military spending are unclear given both the possibility of a new American president and the massive economic hit caused by the COVID-19 pandemic.[1]

The new reality is reflected in the US Department of the Navy's FY2021 funding request of US$207.1bn. This is essentially flat compared with last year's US$205.2bn and little changed from spending a decade ago in real terms. This is creating real problems as the service attempts to undertake a radical reorientation to face 'near peer' competition from China and Russia whilst simultaneously funding a once-in-a-generation renewal of its strategic submarine force. Analysis of the spending breakdown reveals that the priorities are reversing the 'hollowing out' of capabilities that occurred during the Obama years, with more money being directed to the maintenance of ships and aircraft, as well as the acquisition of new weapons. Whilst lacking a certain glamour, this prioritisation seems sensible and is in line with the budget's stated objective of continuing '…to strengthen military readiness, delivering a force ready now and in the future'.[2]

The trade-off is a significant reduction in the amount of funding allocated to both warship and aviation procurement, which falls by a total of US$6.6bn or 15 percent year-on-year. This is seemingly diametrically opposed to the aim of achieving a 355-ship 'battleforce'; an objective set out in the latest 2016 Force Structure Assessment (FSA) and supported by the current administration. The navy is currently working on a new FSA – known as the Integrated Naval Force Structure Assessment (INFSA) because it also incorporates US Marine Corps structural requirements – which was due to be published in late 2019 but has been repeatedly delayed. The new structure is reportedly driven by the new Distributed Maritime Operations (DMO) concept – more fully explained in Chapter 4.4 – under which widely-dispersed units are linked by technology into an integrated whole. The fact this may well require more, rather than fewer, ships may be part of the problem.[3]

Another complicating factor is the impact of the 'revolving door' of top-level defence appointments that has typified the Trump administration. The Department of the Navy has seen four navy secretaries or acting secretaries – Richard V Spencer, Thomas Modly, James E McPherson and Kenneth Braithwaite – in the last 12 months. This has resulted in reports that the Department of Defense has essentially seized control of the INFSA process, with the navy left with only a limited vote on its future direction. Defense Secretary Mark Esper is believed to favour an acceleration of the divestment of aircraft carriers and larger surface combatants that was evident, for example, in last year's budget request to free up money for smaller warships and unmanned vessels. As well as potentially reducing the US Navy's current 'presence' role that is aimed at deterring conflict, this strategy would inevitably run into strong opposition from politicians representing the country's existing shipbuilding base.

Meanwhile, July 2019 saw the release of the findings of an Argentine commission set up to investigate the loss of the submarine *San Juan* and her entire crew two years previously. Rejecting hypotheses that the submarine was attacked by a foreign warship or hit by a fishing vessel, the commission concluded that command inefficiencies combined with a lack of maintenance in an environment of reduced budgets were the key factors behind the loss. The submarine's commander had reported a fire in the boat's No 3 battery as a result of a seawater leak through the ventilation system, subsequently losing contact after the submarine later submerged to check repairs. The incident should be a salutary lesson to the many navies newly embarking on submarine operations of the large commitment in both money and technical resources required to run a safe and effective underwater force.[4]

The second *Ford* class carrier *John F. Kennedy* (CVN-79) pictured being floated out of Newport News Shipbuilding's Dry Dock 12 on 17 December 2019. The ship had been floated up within the dock in October but was only transferred to the final fitting-out berth after her christening on 7 December. The long-term future direction of aircraft carrier construction for the US Navy is becoming more uncertain as the fleet starts to embrace a Distributed Maritime Operations concept that requires investment in large numbers of smaller warships. *(Huntington Ingalls Industries)*

Table 2.1.1: FLEET STRENGTHS IN THE AMERICAS – LARGER NAVIES (MID 2020)

COUNTRY	ARGENTINA	BRAZIL	CANADA	CHILE	COLOMBIA	ECUADOR	PERU	USA
Aircraft Carrier (CVN/CV)	–	–	–	–	–	–	–	11
Strategic Missile Submarine (SSBN)	–	–	–	–	–	–	–	14
Attack Submarine (SSN/SSGN)	–	–	–	–	–	–	–	56
Patrol Submarine (SSK)	2	5	4	4	4	2	6	–
Fleet Escort (CG/DDG/FFG)	4	7	12	8	4	2	7	92
Patrol Escort/Corvette (FFG/FSG/FS)	9	2	–	–	1	6	2	22
Missile Armed Attack Craft (PGG/PTG)	2	–	–	3	–	3	6	–
Mine Countermeasures Vessel (MCMV)	–	4	12	–	–	–	–	11
Major Amphibious Units (LHD/LPD/LPH/LSD)	–	2	–	1	–	–	1	33

Note: Many units in the Argentine and Brazilian fleets are not operational.

MAJOR NORTH AMERICAN NAVIES – CANADA

As illustrated by Table 2.1.2, there has been no material change in the principal components of the Royal Canadian Navy year-on-year. With the country's 2017 defence policy review largely confirming previous procurement plans, the current focus is on implementing new construction programmes. These are being delivered in accordance with the overarching National Shipbuilding Strategy (NSS). Announced in 2010, this essentially resulted in all shipbuilding work on large government vessels being allocated to Irving Shipbuilding in Halifax and Seaspan's Vancouver Shipyards. In December 2019, it was announced a third major Canadian shipyard – Chantier Davie of Quebec – had pre-qualified to become the third strategic partner under the strategy in a move widely considered to have been driven more by political than by industrial or defence considerations.[5]

It is probably fair to say that implementation of the NSS is having mixed success. The most advanced procurement programme is for the new *Harry DeWolf* class Arctic and offshore patrol vessels, which is being implemented by Irving in Halifax. Following revisions in 2018 and 2019, this now encompasses six ships for the navy and an additional two for the coast guard. Delivery of the lead ship was expected to take place during 2018 when the construction contract was announced in January 2015 but this date has suffered from progressive delays. Sea trials of *Harry DeWolf* finally commenced on 22 November 2019 but the ship had not been accepted at the time the coronavirus pandemic halted work at the shipyard in March. As of mid-2020, a new delivery date had yet to be announced. Work has now resumed on at least three other members of the class. The second ship – *Margaret Brooke* – had previously been floated out on 10 November 2019.

Work is also now well underway on the construction of two joint support ships allocated to Seaspan at Vancouver. Named *Protecteur* and *Preserver* after two previous Canadian replenishment vessels, they are based on ThyssenKrupp Marine Systems' Type 702 *Berlin* class design. Fabrication of early blocks for the ships commenced in mid-2018 but it was only in January 2020 that a formal keel-laying ceremony for the first ship took place. She is expected to be delivered in 2023, with her sister following two years later. In June 2020 Seaspan was awarded a CAD$2.4bn contract to complete construction of the vessels, taking total programme costs to a massive CAD$4.1bn (US$3bn). As the NSS effectively involves rebuilding a national shipbuilding industry, significant challenges should be expected as the sector regains lost capabilities. Nevertheless, the programme delays and costs incurred with shipbuilding programmes to date must inevitably be of concern given the much larger and expensive project for fifteen new Canadian Surface Combatants – to be built by Irving Shipbuilding to a modified British Type 26 Global Combat Ship design – is still in its infancy.

The last year has also had its difficulties from an operational perspective. Most notably, one of the new CH-148 Cyclone helicopters and its six-strong crew were lost to an accident in the Ionian Sea on 29 April 2020. The helicopter crashed in the course of manoeuvring for a landing whilst deployed with the frigate *Fredericton* as part of NATO's Operation 'Reassurance'. Whilst the flight safety investigation into the circumstances of the accident is still

Margaret Brooke – the second of the Royal Canadian Navy's *Harry DeWolf* class Arctic and offshore patrol vessels – photographed on a floating barge at the time of her launch in November 2019. The programme is running a little behind schedule following delayed delivery of the lead member of the class. *(Irving Industries Inc)*

Table 2.1.2: CANADIAN NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Frigate – FFG	**HALIFAX**	12	4,800 tons	134m x 16m x 5m	CODOG, 29 knots	225	1992
Submarines							
Submarine – SSK	**VICTORIA** (UPHOLDER)	4	2,500 tons	70m x 8m x 6m	Diesel-electric, 20+ knots	50	1990

ongoing, early reports suggest there was a conflict between the rotorcraft's autopilot and instructions given by the human crew. The Cyclone's introduction into Canadian service has proved to be long and difficult, with full operational capability not expected to be achieved before 2025. It is therefore to be hoped that the full causes of the crash are resolved before confidence in the new aircraft is further eroded.

MAJOR NORTH AMERICAN NAVIES – UNITED STATES

The US Navy achieved a 'battleforce' total of 300 ships at the end of June 2020, returning to a number not achieved since 2002-03. This represents a year-on-year increase of ten warships. Continued deliveries of Littoral Combat Ships accounted for nearly half the growth, with the balance spread across a wide range of warship categories. Table 2.1.3 provides an overview of principal warship types as of the mid-year.

Although some progress is being made in rebuilding the fleet, this current total is a long way short of the 355-ship total targeted by the 2016 FSA. Moreover, until the new INFSA process is concluded it is far from clear how the US Navy is going to bridge this gap. This uncertainty is reflected in the delayed production of a new *Annual Long-Range Plan for Construction of Naval Vessels* for Congress, which normally provides a good insight into how the navy sees its future structural development at any particular point in time.[6] Previous plans partly envisaged squaring the circle of growing ship numbers against a likely backdrop of constrained future budgets by seeking the life extension of existing assets. A key element of this plan – first revealed in April 2018 – was the 'no destroyer left behind' programme to increase the service lives of all *Arleigh Burke* (DDG-51) class destroyers to 45 years. However, subsequent reports suggest the future budgetary environment has resulted in this ambition being revised.[7] Moreover, recent Department of the Navy pronouncements run counter to the previous approach in seemingly targeting the accelerated withdrawal of so-called 'legacy assets'. This includes the progressive reduction of planned *Ticonderoga* (CG-47) class cruiser modernisations, early disposal of the first four Littoral Combat Ship prototypes and even a start of withdrawing the *Whidbey Island* (LSD-41) dock landing ships.

It is also not yet evident that accelerated construc-

The *Halifax* class frigate *Fredericton* pictured entering Portsmouth Harbour on 2 June 2020 during a deployment to Europe as part of NATO's Operation 'Reassurance'. On 29 April 2020 the ship's embarked CH-148 Cyclone helicopter and its six-strong crew were lost in a tragic accident in the Ionian Sea. *(Conrad Waters)*

The *Freedom* (LCS-1) variant *Indianapolis* (LCS-17) pictured in the course of transit to her new home base in Florida on 13 November 2019 after being commissioned at Burns Harbor on Lake Michigan on 26 October. Deliveries of new Littoral Combat Ships have been the driving force behind a small increase in the number of US Navy warships over the past twelve months. *(Marc Piché)*

tion of new vessels is going to close the gap. This is apparent from Table 2.1.4, which shows the planned procurement of new warships over the five years of the Future Years Defense Program (FYDP). It can be seen that the programme envisages a marked reduction over the previous year's figures. More specifically, total acquisitions between FY2021 to FY2025 are expected to fall by twelve from the fifty-four ships included in last year's shipbuilding plan to just forty-two; or by a net ten if two ships brought forward to FY2020 by Congressional action are discounted. Half of the reduction is contributed by a marked slowdown in purchases of DDG-51 destroyers, which fall from thirteen to eight during the period in question. This clearly reflects the increasing shift in emphasis towards the procurement of smaller warships. Many of the other reductions appear to be driven by budgetary pressures. The reduced pace of acquisitions of *John Lewis* (T-AO-205) oilers seems a particularly perverse decision given the importance of these to implementing the DMO concept that is apparently driving future force development.

One other signal of future intent is the planned procurement of growing numbers of large unmanned surface vessels over the medium term. Costing only possibly a tenth of the price of a DDG-51 destroyer or a fifth of that of a new frigate, they offer a cut-price way to boosting the fleet's firepower; although only if they can be made to work effectively. Their procurement is expected to step up to a rate of three p.a. by FY2025. More broadly, it seems reasonable to speculate that the current shipbuilding programme is something of a 'placeholder' pending completion of the new INFSA and the development of associated next generation design concepts. As such, it seems that further changes of plan are likely once INFSA's conclusions are approved.

In the meantime, more details of current developments relating to major warship types are provided below.[8]

Aircraft Carriers: Beyond combatting the potential impact of COVID-19 on its operational carrier force, the US Navy's main objective over the past year has been getting the next generation *Gerald R. Ford* (CVN-78) to work correctly. With many problems relating to the ship's propulsion system, electromagnetic aircraft launch system (EMALS) catapults and advanced arrester gear (AAG) now seemingly in the past, a major focus has been bringing the carrier's elevators into operational service. Recent reports suggest there is a shrinking 'to do' list, reducing the time before *Ford* can enter the operational cycle. It is

Table 2.1.3: UNITED STATES NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CVN	**FORD** (CVN-78)	1	100,000 tons+	333m x 41/78m x 12m	Nuclear, 30+ knots	4,600	2017
Aircraft Carrier – CVN	**NIMITZ** (CVN-68)	10	101,000 tons	333m x 41/78m x 12m	Nuclear, 30+ knots	5,200	1975
Principal Surface Escorts							
Cruiser – CG	**TICONDEROGA** (CG-47)	22	9,900 tons	173m x 17m x 7m	COGAG, 30+ knots	365	1983
Destroyer – DDG	**ZUMWALT** (DDG-1000)	2[1]	15,800 tons	186m x 25m x 8m	IEP, 30+ knots	175	2016
Destroyer – DDG	**ARLEIGH BURKE** (DDG-51) – Flight II-A	40	9,400 tons	155m x 20m x 7m	COGAG, 30 knots[1]	320	2000
Destroyer – DDG	**ARLEIGH BURKE** (DDG-51) – Flights I/II	28	8,900 tons	154m x 20m x 7m	COGAG, 30+ knots	305	1991
Littoral Combat Ship – FS	**FREEDOM** (LCS-1)	10	3,500 tons	115m x 17m x 4m	CODAG, 45+ knots	‹50[2]	2008
Littoral Combat Ship – FS	**INDEPENDENCE** (LCS-2)	12	3,000 tons	127m x 32m x 5m	CODAG, 45+ knots	‹50[2]	2010
Submarines							
Submarine – SSBN	**OHIO** (SSBN-726)	14	18,800 tons	171m x 13m x 12m	Nuclear, 20+ knots	155	1981
Submarine – SSGN	**OHIO** (SSGN-726)	4	18,800 tons	171m x 13m x 12m	Nuclear, 20+ knots	160	1981
Submarine – SSN	**VIRGINIA** (SSN-774)	19	8,000 tons	115m x 10m x 9m	Nuclear, 25+ knots	135	2004
Submarine – SSN	**SEAWOLF** (SSN-21)	3[3]	9,000 tons	108m x 12m x 11m	Nuclear, 25+ knots	140	1997
Submarine – SSN	**LOS ANGELES** (SSN-688)	30	7,000 tons	110m x 10m x 9m	Nuclear, 25+ knots	145	1976
Major Amphibious Units							
Amph. Assault Ship – LHD	**AMERICA** (LHA-6)	2	45,000 tons	257m x 32/42m x 9m	COGAG, 22+ knots	1,050	2014
Amph Assault Ship – LHD	**WASP** (LHD-1)	8[4]	41,000 tons	253m x 32/42m x 9m	Steam, 20+ knots	1,100	1989
Landing Platform Dock – LPD	**SAN ANTONIO** (LPD-17)	11	25,000 tons	209m x 32m x 7m	Diesel, 22+ knots	360	2005
Landing Ship Dock – LSD	**WHIDBEY ISLAND** (LSD-41)	12[5]	16,000 tons	186m x 26m x 6m	Diesel, 20 knots	420	1985

Notes:

1 Includes one ship commissioned but not fully operational pending completion of combat systems installation.

2 Plus mission-related crew.

3 Third of class, SSN-23 is longer and heavier.

4 LHD-8 has many differences.

5 Includes four LSD-49 HARPERS FERRY variants.

envisaged that the current post-delivery test and trials period will be followed by first-of-class shock trials in the course of 2021. The carrier will then return to dock to make good any defects before preparing to join the front-line fleet.

The second *Ford* class carrier, *John F. Kennedy* (CVN-79), was floated up in dock in October 2019 and formally christened on 7 December. The current aim is for her to undertake preliminary trials in the first half of 2022. However, final delivery is not anticipated until September 2024, as much electronic equipment will only be installed after these initial tests have taken place. She will enter the deployment cycle in 2027, replacing *Nimitz* (CVN-68). Keel laying of *Enterprise* (CVN-80) is anticipated in February 2022 and that of the newly named *Doris Miller* (CVN-81) in January 2026. There is considerable uncertainty over plans for subsequent aircraft carriers, which are discussed further in Chapter 4.1.

Surface Combatants: The US Navy continues to split its surface fleet between large surface combatant (destroyers and cruisers) and small surface combatant (frigates, Littoral Combat Ships and mine countermeasures vessels) elements. The former has benefitted from the arrival of two units over the past 12 months. One is that of the stealth destroyer *Zumwalt* (DDG-1000), which joined the active 'battleforce' on 24 April 2020 after completion of combat systems installation. However, initial operational capability is not expected before the end of 2021. Meanwhile, the same day saw delivery of the DDG-51 class destroyer *Delbert D. Black* (DDG-119) from the Ingalls Industries shipyard of Huntington Ingalls Industries (HII) at Pascagoula, Mississippi. She is the 68th member of a class that will reach its 30th service anniversary in mid-2021.

Construction of DDG-51 class destroyers continues under multi-year procurement contracts split between HII and its Maine-based rival General Dynamics Bath Iron Works that were awarded in September 2018. These cover the period between FY2018 and FY2022 and included an option for the third destroyer approved in the FY2020 budget that

Table 2.1.4: USN FY2021 FIVE YEAR SHIPBUILDING PLAN (FY2021-FY2025)

SHIP TYPE	FY2020 REQUEST	FY2020 FUNDED	FY2021 REQUEST[1]	FY2022 PLAN[1]	FY2023 PLAN[1]	FY2024 PLAN[1]	FY2025 PLAN[1]	FY2021-25 TOTAL FYDP[1]
Aircraft Carrier (CVN-78)	1	1	– (–)	– (–)	– (–)	– (–)	– (–)	**– (–)**
Strategic Submarine (SSBN-826)	–	–	1 (1)	– (–)	– (–)	1 (1)	– (–)	**2 (2)**
Attack Submarine (SSN-774)	3	2	1 (2)	2 (2)	2 (2)	2 (2)	2 (2)	**9 (10)**
Destroyer (DDG-51)	3	3	2 (2)	2 (2)	1 (3)	2 (3)	1 (3)[1]	**8 (13)[1]**
Future Frigate (FFG(X))	1	1	1 (2)	1 (2)	2 (2)	2 (2)	3 (2)	**9 (10)**
Amphibious Assault Ship (LHA-6)	–	1[2]	– (–)	– (–)	– (–)	– (1)[2]	– (–)	**– (1)**
Amphibious Ship (LPD-17 F II)	–	1[2]	– (1)[2]	– (–)	1 (1)	– (–)	1 (1)	**2 (3)**
Expeditionary Fast Transp't (T-EPF-1)	–	1	–	–	–	–	–	**– (–)**
Expeditionary Sea Base (T-ESB-3)	–	–	–	–	– (1)	–	–	**– (1)**
Replenishment Oiler (T-AO-205)	2	2	– (1)	– (1)	1 (2)	2 (1)	1 (1)	**4 (6)**
Submarine Tender (AS(X))	–	–	–	–	–	1 (–)	– (1)	**1 (1)**
Fleet Tug (T-ATS)	2	2	2 (1)	1 (1)	– (1)	– (–)	–	**3 (3)**
Surveillance Ship (T-AGOS(X))	–	–	–	1 (1)	1 (1)	1 (1)	1 (1)	**4 (4)**
Total	**12**	**14**	**7 (10)**	**7 (9)**	**8 (13)**	**11 (11)**	**9 (11)**	**42 (54)**

Notes

1 Figure in brackets relates to the total of number of ships planned for the same FY2021–25 period at the time of last year's FY2020 budget submission. Details provided beyond the life of any FYDP become more limited so there is some uncertainty over the precise classes of ship proposed for FY2025 at the time of last year's budget. For example, it is understood one of the three large surface combatants initially planned for procurement in FY2025 was to have been the first of a new class of large surface vessel, not a DDG-51.

2 There is something of a dispute between Congress and US Navy as to which years these two ships fall within; Congress funded them as additions to the Department of the Navy's 2020 submission but the navy's FY2021 budget submission confusingly retains the LPD in the year (i.e. FY2021) when procurement was initially envisaged and now lists the LHA in FY2023, stating procurement has been advanced a year from last year's planned FY2024 acquisition. This table lists both ships as being funded in FY2020 in line with the Congressional action. There is something of a similar debate as to when the FY2020 aircraft carrier should be listed but this table retains the position shown in US Navy documents in its regard.

The latest *Arleigh Burke* (DDG-51) class destroyer to be delivered, *Delbert D. Black* (DDG-119), is pictured in the course of trials in the Gulf of Mexico in February 2020. She is the 68th member of a class that will reach its 30th service anniversary in mid-2021. *(Huntington Ingalls Industries)*

The future of the US Navy's fleet of small surface combatants is in the hands of the new FFG(X), which will be built by Fincantieri at Marinette Marine, Wisconsin to a modified Italian FREMM variant design. In the editor's opinion, this graphic – released at the time of contract award – lacks something of the flare of the Italian original in spite of President Trump's claims that he has intervened to make navy ships 'beautiful'. *(US Navy)*

was ultimately allocated to HII on 30 June 2020.[8] The outlook for the two yards looks a little gloomier in the medium term given the decline in the proposed rate of construction of major surface combatants from an average of 2.5 units p.a. to 1.5 units p.a. from FY2023 onwards. Shipyard assembly is now transitioning to the DDG-51 Flight III design – incorporating the Raytheon AN/SPY-6 active array formerly known as the AMDR air and missile defence radar – following a formal keel-laying ceremony for *Jack H. Lucas* (DDG-125) on 8 November 2019. Longer-term plans to switch production to a new large surface combatant design continue to be pushed back. Having already been deferred from FY2023/FY2024 to FY2025 last year it now seems that it will not be until FY2028 that the first of the new ships will be bought.

Meanwhile series deliveries of Littoral Combat Ships have continued to swell small surface combatant numbers. Four ships – the *Freedom* (LCS-1) variants *Indianapolis* (LCS-17) and *St Louis* (LCS-19) along with their *Independence* (LCS-2) class counterparts *Kansas City* (LCS-22) and *Oakland* (LCS-24) – have been accepted over the past year. This takes deliveries to 22 out of the total 35-vessel type. However, further expansion of the smaller surface warships looks to be curbed in the short term both by long-planned withdrawals of *Avenger* (MCM-1) class mine countermeasures vessels and the more recently announced decision to retire the four prototype Littoral Combat Ships. It would take considerable sums to modernise these units to the standards of the later, series-built units. Even though the youngest has been in service for only a little over six years, the navy believes the money can be better devoted to meeting other priorities.

With the final Littoral Combat Ships funded under the FY2019 programme, future small combatant construction will become increasingly dominated by the follow-on FFG(X) frigate. On 30 April 2020 Fincantieri's Marinette Marine yard in Wisconsin was awarded a firm contract for the lead ship in the programme and nine further optional vessels based on a proposal for construction of an evolved variant of the Italian Navy's multi-mission FREMM frigate. The new ship will be heavier (7,400 tons vs 6,700 tons), longer (152m vs 144m) and broader (19.8m vs 19.7m) than the parent design and will be equipped with a combat and weapons systems common to other US combatants. The estimated cost of the first ship is c. US$1.3bn – of which US$795m is the value of the detailed design and construction contract – but it is hoped that the unit cost of the third and following ships will fall to around US$940m in FY2021 terms. The contract is good news for the Marinette Marine shipyard, ensuring an ongoing workload when construction ends on the LCS-1 type ships and the four evolved multi-mission surface combatants ordered by the Royal Saudi Navy.[9]

Efforts to field unmanned warships – that will ultimately include both missile-armed large unmanned surface vehicles (LUSVs) and sensor-carrying medium unmanned surface vehicles (MUSVs) – are a high priority but still in their relative infancy. Congress supported the acquisition of two developmental prototype LUSVs in their FY2020 appropriations. However, the planned integration of a vertical launch system (VLS) into the vessels will not take place for the time being due to concerns over the maturity of the concept. The FY2021 budget request gave a nod to Congressional scepticism, delaying acquisition of operational vessels until FY2023 to allow purchase and testing of additional developmental prototypes in the interim. However, design contracts for these vessels and a similar MSUV prototype funded in FY2019 have been delayed. Testing of unmanned and autonomous concepts by the new Surface Development Squadron 1 (SURFDEVRON) formed in May 2019 is therefore currently restricted to the older medium-sized *Sea Hunter* research vessel, originally funded by the Defense Advanced Research Projects Agency (DARPA). This work will step up over the coming year as other interim vessels are acquired or transferred to its control, initially through the delivery of a second *Sea Hunter* expected early in 2021.

Amphibious and Support Shipping: The last year has seen the US Navy's front-line amphibious forces bolstered by the delivery of the new amphibious assault ship *Tripoli* (LHA-7), the second member of the *America* (LHA-6) class. Other arrivals have included the third expeditionary mobile base –

Miguel Keith (T-ESB-5) – and the eleventh *Spearhead* (T-EPF-1) class expeditionary fast transport vessel, *Puerto Rico* (T-EPF-11). Whilst both these ships were delivered to the US Navy's Military Sealift Command, it has been determined that all the expeditionary mobile bases will serve as commissioned US Navy ships following a decision to use them in a more offensive role. This approach was first taken when the lead member of the class – *Lewis B. Puller* (ESB-3) – deployed to the Persian Gulf in 2017 and has subsequently seen the transfer of *Hershel "Woody" Williams* (ESB-4) from the Military Sealift Command on 7 March 2020.

The US Navy's amphibious forces seemingly did well out of the FY2020 budget authorisations, which accelerated funding both for LHA-9 – the fourth *America* class amphibious assault ship – and for LPD-31, the second member of the LPD-17 Flight II amphibious transport dock iteration. Money was also provided for an additional *Spearhead* fast transport, the fifteenth member of the class. The largesse appears to relate as much to the industrial requirements of building yards HII and Austal USA and their Congressional supporters as it does to naval priorities. Austal's Mobile yard, in particular, faces future uncertainty as the *Independence* and *Spearhead* programmes start to draw to a close. In the event, it may be that any celebrations surrounding the LHA-9 and T-EPF-15 allocations were premature, as the Trump administration subsequently took action to divert the funds for their construction into building the controversial Mexican border wall.[10]

The longer-term future of the amphibious force is subject to as much uncertainty as that of the rest of the fleet as US Marine Corps Commandant General David H Berger seeks to reshape the corps to meet the possibility of a new conflict in the Pacific. His latest planning guidance, published in July 2019, specifically states that the previous 38 ship 12+13+13 force construct (i.e. 12 LHA/LHD + 13 LPD-17 + 13 LSD/LPD type ships) no longer holds good. Instead, a different more varied mix of ships – including smaller and even unmanned vessels – will be required in a likely heavily contested environment.[11] There have been reports that these will include a new Light Amphibious Warship (LAW). As many as thirty of these may be ordered, going a long way to bridge the gap to achieving the 355-strong fleet.

The main programme for auxiliary shipping relates to construction of *John Lewis* class oilers at General Dynamics NASSCO in California. Work on the first ship was around two-thirds complete at the start of 2020 and fabrication of the second vessel, *Harvey Milk* (T-AO-206) had already commenced at that time. However, assembly of *John Lewis* was running around seven months behind schedule, pushing planned delivery back from November 2020 to July 2021. NASSCO has a block build contract for a total of six vessels but at least twenty will be required in due course.

On 3 April 2020, Huntington Ingalls Industries announced it had been awarded a US$1.5bn contract modification for the detailed design and construction of LPD-31, the as-yet unnamed second *San Antonio* (LPD-17) Flight II amphibious transport dock. Construction of the ship was accelerated as a result of congressional action on the navy's FY2020 budget request. This HII graphic is the latest available of the proposed Flight II design, which incorporates some simplifications compared with the previous flight. *(Huntington Ingalls Industries)*

Submarines: There is seemingly a much greater consensus around the future structure of the US Navy's underwater arm than of its surface fleet, with most stakeholders agreeing that more attack submarines of the existing *Virginia* (SSN-774) class are needed. However, the force still faces significant industrial and financial challenges maintaining existing rates of production of these vessels whilst embarking on construction of the new *Columbia* (SSBN-826) class strategic submarines that will form a key constituent of the future American nuclear deterrent.

US submarine construction has long been dominated by General Dynamics Electric Boat at Groton Connecticut and HII's Newport News yard in Virginia. The facilities have collaborated in the production of the *Virginia* submarines, earning an enviable reputation for timely delivery of earlier members of the class. The design has been progressively improved through the production of different 'Blocks'. The last twelve months have seen the transition from Block III to Block IV deliveries, with the acceptance of the final Block III boat – *Delaware* (SSN-791) – from HII in October 2019 being followed by the arrival of the first Block IV submarine – *Vermont* (SSN-792) – from General Dynamics on 16 April 2020. However, attempts to accelerate production have come unstuck as weaknesses in the supply chain have increasingly impacted delivery schedules. In February 2020 it

was reported that the average delay for Block IV production had reached over ten months. *Montana* (SSN-794), the third of the ten-boat batch, is reportedly running as much as 15 months behind schedule.[12] This bottleneck is proving to be a real headache for the US Navy, as the submarine force is currently predicted to shrink substantially in the decade ahead due to wholesale withdrawals of remaining Cold War-era boats.

The submarine enterprise is therefore already under pressure as it faces two additional hurdles. One is the pending move to constructing Block V *Virginia* class submarines. These will introduce acoustic improvements and, more importantly, the Virginia Payload Module (VPM). This is an additional, c. 25m mid-body section fitted with four large-diameter vertical launch tubes for up to twenty-eight Tomahawk cruise missiles or other loadouts. Clearly, introduction of this new capability will add cost and complexity to the programme. The other, even more significant hurdle is the need to ramp up capacity still further to build the twelve planned new *Columbia* class boats, which will replace the remaining fourteen *Ohio* (SSBN-726) strategic submarines from 2031 onwards. This hugely expensive project is estimated to cost around US$110bn in procurement costs alone and is currently regarded as the US Navy's highest priority. Inevitably, accommodating these costs within an already-stretched budget is taking away resources from lower-priority construction.

Steps have been taken to try to address some of these challenges over the last year. In December 2019 General Dynamics – lead contractor for the *Virginia* programme – was awarded a c. US$22.2bn multi-year procurement contract for nine new Block V submarines, eight of which will incorporate the VPM. The contract covers acquisitions over the FY2019 to FY2023 timeframe. In a change to previous arrangements – under which both yards involved in the programme supplied components for each submarine but with alternated assembly between the two – Newport News will take responsibility for assembling six of the Block Vs and General Dynamics only three. This frees up General Dynamics to undertake the bulk of *Columbia* class production, most particularly all final assembly work. In June 2020, the company received a contract modification potentially worth up to US$9.5bn if options are exercised to continue preparations to build the first two members of the *Columbia* class. Current plans envisage construction of SSBN-826 commencing in October 2020, followed by the as yet unnamed SSBN-827 in the course of FY2024.

The revised contractual arrangements potentially ease industrial capacity issues at the shipyards but the supply chain remains a potential vulnerability. Moreover, funding remains a problem and was reflected in the reduction of the *Virginia* Block V contract from an expected ten (or more) submarines to the nine finally agreed. The contract includes an option for an additional tenth boat to be assembled by General Dynamics, which Congress may fund in FY2021 to maintain a steady two p.a. 'drumbeat' of *Virginia* class construction. This submarine is listed as the US Navy's most important unfunded priority and has significant political support, not least to prevent the fluctuation in component demand that would otherwise occur.

As in the surface sphere, the US Navy envisages manned submarines being increasingly supplemented by various types of unmanned underwater vehicle (UUV) of sizes up to and including extra-large unmanned undersea vehicles (XLUUVs) that are too large to be launched from a manned submarine. In early 2019 Boeing was awarded contracts to build five 'Orca' XLUUVs based on its Echo Voyager UUV. Further Orcas are expected to be acquired at a rate of two p.a. from 2023. One of the Echo Voyager's main benefits is its ability to accommodate a modular payload section up to 10m in length. Orca is expected to build on this design element to provide the US Navy with a broad unmanned underwater multi-mission capability.

The last Block III *Virginia* class submarine, *Delaware* (SSN-791), pictured in the course of sea trials in August 2019. Delivered in October of that year, the COVID-19 crisis prevented the usual commissioning celebration from being held and – in a unique departure from the norm – she became the first US Navy vessel to be commissioned underwater. Irrespective of the potential impact of the pandemic, US submarine construction is already under huge pressure as the transition to Block V *Virginia* class construction coincides with the start of work on the new *Columbia* class strategic submarines. *(Huntington Ingalls Industries)*

Operational Highlights: The operational snapshot provided in the press briefing that accompanied the US Navy's FY2021 budget request suggested 108 ships of the then 293-strong battleforce were deployed at the end of January 2020. This is materially higher than the ninety-one ships deployed as of 8 March 2019 but seems to a somewhat atypical

The aircraft carriers *Theodore Roosevelt* (CVN-71) in the foreground and *Nimitz* (CVN-68) pictured underway together as the *Theodore Roosevelt* and *Nimitz* Carrier Strike Groups conducted dual carrier and air wing operations in the Philippine Sea on 23 June 2020. The US Navy conducted a series of dual carrier operations around this time to demonstrate America's continued willingness to counter Chinese expansionism in spite of the challenges created by the COVID-19 pandemic. *(US Navy)*

peak as the number is expected to fall back to ninety-eight by the end of the current fiscal year in September 2020. Indeed, a glance back at previous press briefings suggests that the navy has struggled to shift deployments materially out of the 90–100 ship range in recent years in spite of the slight increase in overall fleet size. This may partly reflect a combination of a continued maintenance backlog and the more cautious approach being taken to ensuring ships are fully ready for deployment referenced in previous editions of *Seaforth World Naval Review.*

From a geographical perspective, it is clear that the Asia Pacific region continues to be the US Navy's major area of focus. A total of sixty-one ships – including two carrier strike groups and an amphibious expeditionary strike group – were deployed in the region in January 2020, with a further ninety-six ships located on the Pacific Coast. In June 2020 the *Nimitz* (CVN-68) carrier strike group carried out successive dual carrier operations with the *Theodore Roosevelt* (CVN-71) and *Ronald Reagan* (CVN-76) groups in the Philippine Sea, possibly in preparation for freedom of navigation exercises in the South China Sea. The operations – reportedly the largest in the region since 2017 – were seen as demonstrating the United States' ongoing willingness to face down Chinese expansionism in the area despite the challenges posed by the ongoing COVID-19 pandemic.[13]

Although Pacific waters are the navy's clear priority, many other demands are being placed on the fleet. Prominent amongst these are the need to maintain maritime security in the Persian Gulf in the face of Iranian provocations. One major development was the formation of the US Navy-led International Maritime Security Construct to protect shipping in the area in September 2019. Deployments have also extended to somewhat chiller seas in response to the re-emergence of Russian militarism, with the Arctic becoming one area of much greater strategic interest. At the start of May 2020, US Navy warships entered the Barents

A picture of a fast drug-running boat captured by the destroyer *Pinckney* (DDG-91) on 15 May 2020, shortly after an announcement that the United States would deploy additional navy, Coast Guard and other assets to the Caribbean and Eastern Pacific as part of an enhanced counter-narcotics response. Some commentators have suggested the policy is as much about putting pressure on the Venezuelan Maduro presidency as it is about stepping up the war on drugs. *(US Navy)*

Sea north of Russia in company with the Royal Navy frigate *Kent* to conduct their first operations in the area since the end of the Cold War.

Closer to home, tensions with Venezuela's Maduro regime remain high. Freedom of navigation operations were conducted off the country's coast by the Littoral Combat Ship *Detroit* (LCS-7) and the destroyer *Nitze* (DDG-94) in, respectively, January and June 2020. In April 2020, the United States announced a major beefing-up of counter-narcotics forces in the Caribbean and Eastern Pacific that will include the deployment of additional naval and Coast Guard vessels to the region. Many see the move as having as much to do with keeping up pressure on the Maduro presidency as achieving meaningful progress in the fight against drugs.

US Coast Guard: One increasingly useful asset available to support operations by the US Navy's frontline warships is the US Coast Guard's constabulary-orientated fleet. This is being more widely used across the globe in support of maritime security operations, with the recent deployments of the California-based national security cutters *Bertholf* (WMSL-750) and *Stratton* (WMSL-752) under the operational control of the US 7th Fleet in the Pacific indicative of a longer-term trend.[14] The 162-day *Stratton* deployment – from June to November 2019 – saw the ship undertake capacity-building exercises with a number of regional navies and coast guards whilst helping enforce sanctions against the North Korean regime. The voyage helped to demonstrate the improved capabilities of the new generation of cutters that have been entering Coast Guard service in recent years, of which the 'Legend' or *Bertholf* class are the largest and most capable. *Kimball* (WMSL-756) and *Midgett* (WMSL-757) – respectively the seventh and eighth members of the eleven-strong class – were formally commissioned at a joint ceremony in Honolulu on 24 August 2019. The ninth, named *Stone* (WMSL-758), was launched in October 2019 prior to formal christening on 29 February 2020.

Whilst there is some support for a twelfth member of the 'Legend' class – thereby replacing the previous *Hamilton* (WHEC-715) high endurance cutters on a one-for-one basis – the Coast Guard's attention is increasingly turning to the new, only slightly smaller intermediate-size 'Heritage' class offshore patrol cutters. These are estimated to cost around US$410m per unit compared with some US$670m for each of the 'Legends', possibly reflecting a planned longer production run of twenty-five ships. Construction of the initial members of the class has been allocated to Eastern Shipbuilding in Panama City, Florida but the contract for vessels from the fifth ship onwards will be re-competed following shipyard problems in the aftermath of Hurricane Michael in December 2018. Eastern Shipbuilding laid the keel of the lead ship, *Argus* (WMSM-915), on 28 April 2020. Fabrication work on the second – *Chase* (WMSM-916) – started the previous day. The Coast Guard's FY2021 budget includes a request for the third ship.

Deliveries of the smaller Damen Stan patrol 4708 'Sentinel' class fast response cutters that form the third new class of vessels destined to recapitalise the Coast Guard's fleet proceed apace. A further five have been delivered by Bollinger Shipyards since the end of June last year, taking the total number to thirty-nine vessels. Sixty out of a total requirement for sixty-four of the c. US$65m ships have been approved to date but no additional orders were included in the coast guard's FY2021 budget submission. At the other end of the scale, the FY2021 budget requests funding for the second of three planned polar icebreakers. Detailed design work continues on the first of the c. 23,000-ton vessels, which is scheduled to commence construction at VT Halter Marine's yard at Pascagoula in the course of 2021.

OTHER NORTH AND CENTRAL AMERICAN NAVIES

Elsewhere in the North and Central American region, **Mexico** has the only navy with the potential for anything beyond purely local constabulary operations.[15] Recent years have seen increasing reliance on its own indigenous shipyards for the construction of new vessels. On 6 February 2020, it achieved a further major step in this process with the delivery of the new *Patrullera Oceánica de Largo Alcance* (POLA) oceanic patrol vessel *Reformador* from the ASTIMAR 20 shipyard in Salina Cruz, Oaxaca. Essentially a light frigate of the Damen 'Sigma 10514' type, the 2,500-ton vessel was assembled from two blocks completed in the Netherlands and a further four

The Mexican Navy commissioned *Reformador* – the first 'Sigma 10514' light frigate built under its POLA programme – on 6 February 2020. The navy would like to buy a total of eight of these vessels to form warfighting flotillas on each of its coasts but it is doubtful whether the current political regime supports further construction. *(Damen)*

fabricated in Mexico. She is by far the most sophisticated warship built in a Mexican yard to date, being equipped with an outfit of weapons and combat systems that provide a real warfighting capability.

Previous reports suggest that the navy would like to acquire two squadrons each of four POLA-type vessels. However, further orders are uncertain given perceptions that the current Mexican Obrador presidency is likely to prioritise social programmes. The navy's own, recently released development plan for 2020–4 seeks to address this issue, emphasising the employment and economic benefits of sustaining shipyard production. It proposes orders for two further POLAs – as well as construction of four additional *Tenochtitlan* class (Damen Stan Patrol 4207) inshore patrol vessels and another *Montes Azules* type logistic support ship – as the main elements of this programme. Pending a final decision on the way forward, the only other imminent arrival is likely to be the eighth and final *Oaxaca* class offshore patrol vessel. The ship – named *Tabasco* – was launched from the ASTIMAR 1 yard in Tampico, Tamaulipas on 27 July 2019 and is expected to be commissioned in the near future. Main armament comprises a BAE Systems/Bofors 57mm gun – also found in *Reformador* and the other three second tranche of *Oaxaca* class vessels – and there are also facilities to embark and support a light helicopter.

Away from Mexico, other recent regional naval procurement includes an AS$126m (US$85m) contract from the coast guard of **Trinidad and Tobago** for two 58m Austal 'Cape' class patrol boats similar to those operated by the Royal Australian Navy and the Australian Border Force. The agreement was signed in August 2019 and envisages delivery of both vessels before the end of 2020. They will join six existing 30m Austal interceptors and a range of Damen-built patrol assets already operated by the force. Damen continues to be a supplier of choice for many naval forces in the region. In June 2020, **Jamaica's** coast guard became the latest recipient of the company's products, taking delivery of the Damen Fast Crew Supplier 5009 *Nanny of the Maroons*. The force already operates the smaller Stan Patrol 4207 vessels *Cornwall* and *Middlesex*.

An interesting development is the expanding role of Colombia's COTECMAR as a supplier of basic but functional warships for Central American fleets. In November 2019 it delivered *Quetzal*, one of its BAL-C landing craft-like logistic support and cabotage vessels, to **Guatemala** under a contract that is understood to contain an option for a second ship of the type. In addition to units completed for the Colombian Navy, a similar vessel was supplied to **Honduras** in 2017 and the company has been working hard to promote the type to other Latin American navies. The latest addition to the Honduran Naval Force has a rather more exotic origin, being an OPV-62 design supplied by Israel Shipyards. Based on the Israeli Navy's SA'AR 4.5 design, the 500-ton *General José Trinidad Cabañas* is a relatively lightly armed but fast ship optimised for constabulary operations. She can accommodate two rigid-hulled inflatable boats (RHIBs) and is equipped with a large flight deck to support helicopter and UAV operations.

MAJOR SOUTH AMERICAN NAVIES – BRAZIL

Although Brazil has yet to escape a difficult underlying economic backdrop, the last 12 months have been relatively good ones for the *Marinha do Brasil.* Notably, there has been further progress with the huge PROSUB construction programme and a firm contract for the acquisition of new frigates has been signed.[16]

Following launch at the giant Itaguaí submarine complex on 14 December 2018, the lead Brazilian 'Scorpène' class submarine, *Riachuelo*, has been undertaking an extensive set of harbour acceptance trials, as well as an initial static dive test. The seagoing phase of the trials is expected to take up much of the remainder of the year, culminating in the submarine's planned delivery and commissioning set for October 2020. The second of the four 'Scorpènes' – *Humaitá* – is now structurally complete after hull closure in October 2019 and her launch is said to be imminent. Launches of the two remaining boats are likely to follow at roughly annual intervals, although it is reasonable to assume their trials phase may be shorter. Significant effort also continues on developmental work for Brazil's first nuclear-powered submarine but the project's realisation must still be a decade or more away. Meanwhile, in October 2019, the navy acquired a

In early March 2020 the Brazilian government signed a contract with a TKMS consortium for the local construction of four *Tamandaré* class MEKO type frigates for delivery between 2025 and 2028. The agreement marks a long-awaited start on replacing Brazil's elderly and often dilapidated surface fleet. *(TKMS)*

Table 2.1.5: BRAZILIAN NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Frigate – FFG	**GREENHALGH** (Batch I Type 22)	2	4,700 tons	131m x 15m x 4m	COGOG, 30 knots	270	1979
Frigate – FFG	**NITERÓI**	5	3,700 tons	129m x 14m x 4m	CODOG, 30 knots	220	1976
Corvette – FSG	**BARROSO**	1	2,400 tons	103m x 11m x 4m	CODOG, 30 knots	145	2008
Corvette – FSG	**INHAÚMA**	1	2,100 tons	96m x 11m x 4m	CODOG, 27 knots	120	1989
Submarines							
Submarine – SSK	**TIKUNA** (Type 209 – modified)	1	1,600 tons	62m x 6m x 6m	Diesel-electric, 22 knots	40	2005
Submarine – SSK	**TUPI** (Type 209)	4	1,500 tons	61m x 6m x 6m	Diesel-electric, 22+ knots	30	1989
Major Amphibious Units							
Helicopter Carrier – LPH	**ATLÂNTICO** (OCEAN)	1	22,500 tons	203m x 35m x 7m	Diesel, 18 knots	490	1998
Landing Ship Dock – LSD	**BAHIA** (FOUDRE)	1	12,000 tons	168m x 24m x 5m	Diesel, 20 knots	160	1998

'new' submarine rescue ship – the former offshore support vessel *Adams Challenge*, now renamed *Guillobel*, first completed in 2009 – to help safeguard its revamped underwater flotilla and their crews. She was formally commissioned on 12 May 2020.

Meanwhile, last year's announcement that the Águas Azuis consortium of ThyssenKrupp Marine Systems (TKMS), Embraer Defense & Security and Atech was the preferred bidder to construct a quartet of *Tamandaré* class ships – now designated as frigates rather than corvettes – was followed by signature of a formal construction contract on 3 March 2020 at a reported cost of R$9.1bn (c. US$1.7bn). The class will be built in southern Brazil at the Oceana Shipyard in Itajaí, whose acquisition by TKMS was subsequently announced on 20 May. It is understood that the lead ship will have at least 30 percent indigenous content, increasing to 40 percent on the second and subsequent vessels. The 107m, 3,500-ton design is based on MEKO modular technology and will use an Embraer combat management system developed from TKMS subsidiary Atlas Elektronik's technology. Deliveries are now expected to commence in 2025, a year later than anticipated when the preferred contracting team was announced. With the navy's force of major combatants now reduced to just nine frigates and corvettes of variable serviceability, the delay cannot be seen as good news for the hard-pressed surface fleet.

Current Brazilian Navy strength is summarised in Table 2.1.5 and shows no material change year-on-year.[17] Away from the main units listed in the table, October 2019 saw the final decommissioning of the logistic landing ship *Garcia D'Avila*. The former British Royal Fleet Auxiliary *Sir Galahad* acquired in 2007, she was originally completed by the former Swan Hunter yard in 1987 to replace the Falkland Islands War loss of the same name.

OTHER SOUTH AMERICAN NAVIES

Turning to the other South American navies, there is a broad consensus that **Chile's** remains one of the best equipped and most effective on the continent. Current strategy appears to be based on maintaining the capability of the existing front-line combatant force of eight frigates and four submarines through overseas purchases. At the same time the capacity of the indigenous shipbuilding sector is being steadily increased both through new build contracts for second-line vessels and through refit and modernisation programmes of growing complexity.

The last year has seen a continuation of this approach. In December 2019 it was reported that the navy would acquire the recently decommissioned Royal Australian Navy FFG-7 type frigates *Newcastle* and *Melbourne* to replace the former Dutch 'L' (*Jacob van Heemskerck*) class air-defence ships, *Almirante Latorre* and *Capitán Prat*, which had recently been decommissioned. Although the Australian vessels are only a few years younger than the 'L' class frigates, they underwent a major upgrade early in the millennium under the SEA 1390 programme that equipped them with the ability to fire Standard SM-2 and vertical-launched Evolved Sea Sparrow missiles. As such, they provide an area air-defence capability unmatched by any other Latin American fleet. The two ships were formally commissioned in Sydney on 15 April 2020 – taking the names of the frigates they replaced – and subsequently arrived in Chile in mid-June.

The surface fleet's capabilities are also being upgraded by modernisation of the three Type 23 frigates acquired from the United Kingdom in 2005 under a programme being carried out at local shipbuilder ASMAR's Talcahuano yard in conjunction with Lockheed Martin Canada. The project – more fully described in Chapter 3.3 – involves installation of a new combat system, air-defence missiles and sensors. *Almirante Cochrane* – the former *Norfolk* – was the first to complete the process in October 2019 and has now returned to the operational fleet. Next in line is *Almirante Lynch* (the former *Grafton*) which commenced upgrade in mid-2019. Meanwhile, the Talcahuano yard continues to work on the Vard 9-203 type icebreaker *Antártica 1* which was originally scheduled for delivery in 2021 but will probably be delayed by the COVID-19 pandemic. It seems that the ambition is then to construct a series of amphibious transport vessels to replace existing tank landing ships before progressing to construction of fully-fledged frigates.

Argentina, the other member of the 'ABC' club of leading Latin American naval powers, continues to see much of its fleet atrophy from lack of funding. Its remaining submarine fleet is effectively non-operational and there have been reports that a number of laid-up surface vessels – including the destroyer *Heroína* and the frigate *Rosales* – may be scrapped as being beyond economic repair. There have been a number of discussions to acquire second-hand submarines to restore an underwater capability, with purchase of two of the soon-to-be-retired Norwegian Type 210 *Ula* class apparently the currently preferred option. It remains to be seen whether this will result in an actual deal. In the interim, the

A picture of the 'Gowind' type offshore patrol vessel *L'Adroit* under refurbishment for Argentine service, where she has taken the name *Bouchard*. The ship was privately funded by Naval Group and initially loaned to the French Navy. *(Naval Group)*

arrival of *Bouchard* – the Naval Group-built offshore patrol vessel previously leased to the French Navy – in February 2020 provides the fleet with its first new warship for many a year. Three other members of the class are currently under construction in France. Their delivery will provide Argentina with a modern but thinly-spread constabulary capability. In December 2019 it was also announced that the United States had approved the sale of four second-hand P-3C Orion aircraft, restoring the navy's ability to conduct aerial maritime patrol operations.

The other two Latin American countries with significant naval forces are **Colombia** and **Peru.** As for Chile, both countries are placing an increasing emphasis on developing the capabilities of their indigenous naval construction industries. This focus is evident in the Colombian Navy's new Naval Development Plan published in mid-2020, which covers the period out to 2042. It envisages the development of a modern navy based around a core fleet comprising five frigates, four submarine and two amphibious transport docks supplemented by offshore and coastal constabulary assets.[18] Realisation of this fleet will support a continuous programme of construction at local builder COTECMAR, whose capabilities will be further developed by inward transfers of foreign technology. South Korea is one of a number of countries vying to be a preferred partner under these arrangements. It has emerged that a second former South Korean Navy corvette will be transferred to Colombia in 2020, doubtless to demonstrate the value of ongoing collaboration.

The Peruvian Navy is modernising its four Type 209/1200 *Angamos* submarines to extend their operational lives. This photograph shows the lead member of the class exercising with a US Navy MH-60R helicopter off San Clemente Island in the Pacific in November 2019. *(US Navy)*

Neighbouring Peru has also been working in collaboration with South Korea to field new amphibious transport docks and coastal patrol vessels. Construction of the second *Makassar* type LPD, *Paita*, is continuing at SIMA's Callao yard whilst its facility at Chimbote is close to completing assembly of a third pair of *Río Pativilca* coastal patrol boats based on a Korean STX design. SIMA's other major project is the modernisation of four *Angamos* class (Type 209/1200) submarines, with *Antofagasta* joining her sister *Chipana* in the programme at the end of 2019. The navy's two older *Islay* class (Type 209/1100) submarines are not due to be modernised and media reports suggest Peru could be looking to acquire former Brazilian Type 209/1400 class boats as replacements.

Elsewhere in Latin America, **Ecuador** has announced the selection of a German Fassmer MPV70 Mk III design to meet a requirement for a new constabulary vessel. Part of a family of new Fassmer naval vessels designed to combine support and patrol roles, the innovative vessel combines a large flight deck with a stern ramp for RHIB deployment and incorporates an integrated mast. The vessel – to be built by ASTINAVE EP in Guayaquil with the assistance of technical support and material

The Ecuadorian Navy has selected the Fassmer MPV70 Mk III design to meet a requirement for a new multi-role offshore patrol and logistic support vessel. The graphic suggests the ship will have a main armament of a 76mm Oto Melara gun to support RHIB and helicopter operating capabilities. *(Fassmer)*

packages from Fassmer – will significantly increase patrol coverage of the outer extremities of the country's EEZ, particularly off the Galapagos Islands. The navy's coastal patrol capabilities are also to be bolstered by the planned transfer of two former South Korean 'Hae Uri' type coast guard vessels in another sign of that country's interest in bolstering links with the region.

Latin America's two naval laggards are **Uruguay** and **Venezuela.** The Uruguayan Navy has struggled

Notes

1. A good explanation of the compromise budget agreement's impact on defence is provided by Seamus P. Daniels and Todd Harrison, 'What Does the Bipartisan Budget Act of 2019 Mean for Defense?' posted to the Center for Strategic & International Studies site – www.csis.org – on 5 August 2019. The agreement is noteworthy in limiting both the core defence budget and the Overseas Contingency Operations (OCO) funding previously used to circumvent budgetary restrictions.

2. See the Press Briefing 'Department of the Navy: FY 2021 President's Budget'. The total enacted US Navy budget for FY2020 included US$4.8bn for emergency disaster relief, with the underlying US$205.2bn being broadly in line with the sum originally requested in March 2019. The FY2021 request amounts to the inflation-adjusted equivalent of US$172.4bn in terms of FY2010 dollars. This compares with the US$177.1bn actually spent in FY2010 and the inflation adjusted total of US$172.8bn in FY2011.

3. Analysis on the current state of the US Navy's future shipbuilding plans and the issues surrounding them can be found in Ronald O' Rourke's *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress RL32665* (Washington DC: Congressional Research Service, 2020). Like many of Mr O'Rourke's other periodically-updated reports, this has been posted as a public service on the Federation of American Scientists' website at: fas.org/sgp/crs/weapons/. One challenge this year is that the Congressional-mandated *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels* produced annually by the Office of the Chief of Naval Operations has not yet been released this year, making it difficult to assess what the navy's medium-term intentions are.

4. The commission's report stated that the submarine had not been dry-docked since completing mid-life modernisation between 2008 and 2015 in spite of regulations specifying that such an examination should be carried out every two years. The submarine had suffered seawater leakage through a valve, E-19, some months prior to her loss and it was assumed this was the source of the original problem on this occasion. The submarine entered

to obtain funds for meaningful modernisation, leaving much of its small fleet in a poor operational state. There have been reports that China may be willing to transfer vessels to help rectify the situation, although there have been no tangible developments to date. Meanwhile, the grandly titled *Armada Bolivariana de Venezuela* continues to struggle amongst the country's ongoing political and economic crisis. Already depleted by a lack of maintenance and spare parts, the fleet's woes were increased by a rather bizarre incident of self-harm on 30 March 2020 when its Navantia BVL-type offshore patrol vessel *Naiguatá* sank after seemingly deliberately ramming the Portuguese-flagged cruise ship *RCGS Resolute* in a botched interception attempt.[19] The Venezuelan ship had been attempting to arrest the ship whilst in international waters off the country's coast, possibly suspecting it of subversive activities during a time of ongoing tension. However, it had not accounted for the fact that the cruise ship was strengthened for navigation in ice-covered waters and came off badly in collision with its reinforced bow. Fortunately, all the *Naiguatá's* c. 40-strong crew were able to take to the ship's life rafts before she slipped below the waves. The ship's sister – the long-delayed *Comandante eterno Hugo Chávez* – was reportedly in the final stages of sea trials from local shipbuilder DIANCA in early 2020, thereby holding out the consolation of the availability of a replacement in the near term.

an uncontrollable descent after making her final dive, sinking until the water pressure caused her hull to implode.

5. A good summary of the current status of the NSS was provided by J. Craig Stone in an article 'The Demise of the National Shipbuilding Strategy: Is it Inevitable?' posted to the Canadian Global Affairs Institute's site – www.cgai.ca – in October 2019.

6. There is also some evidence that the Pentagon is attempting to restrict the publication of future planning information, for example seeking to classify five-year Future Years Defense Program (FYDP) information on the grounds that it might both inadvertently reveal sensitive information to adversaries and also provide industry with a negotiating advantage. Whilst an argument can be made that a return to classification – dropped in 1989 – is a sensible step given the lack of transparency shown by many other countries, it would also make it far more difficult for politicians, analysts and journalists to hold the US government to account. See further Aaron Mehta, 'Pentagon seeks to classify future year defense spending plans' posted to the *Defense News* site – www.defense news.com – on 30 March 2020.

7. For example see David B. Larter in another *Defense News* article, 'Cost of upgrading Arleigh Burke destroyers may not be worth it, says US Navy' posted on 17 March 2020.

8. Further background reading on many of the programmes covered in these sections is provided by the following Ronald O' Rourke CRS Background and Issues for Congress reports: *Navy Ford (CVN-78) Class Aircraft Carrier Program RS20643*; *Navy DDG-51 and DDG-1000 Destroyer Programs RL32109*; *Navy Frigate (FFG[X]) Program R44972*; *Navy LPD-17 Flight II and LHA Amphibious Ship Programs R43543*; *Navy John Lewis (TAO-205) Class Oiler Shipbuilding Program R43546*; *Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program R41129*; and *Navy Virginia (SSN-774) Class Attack Submarine Procurement RL32418* (all Washington DC: Congressional Research Service, 2020).

9. The award of the contract to Marinette Marine has sparked some controversy as a result of comments made by President Trump when visiting the yard on 25 June 2020 – 'I hear the manoeuvrability is one of the big factors that you were chosen for the contract. The other is your location in Wisconsin, if you want to know the truth' – that some have interpreted as indicating that Maine's status as a key marginal electoral state influenced the decision. More bizarrely, the president also suggested that he had personally intervened to improve the appearance of recent warship designs, 'The ships that they were building, they looked terrible. I changed designs. I looked at it. I said, "That's a terrible-looking ship. Let's make it beautiful. It'll cost you the same, and maybe less." You know, sometimes, you can make it look great for less money.' See further, for example, Marcus Weisgerber, 'Trump Says Wisconsin Shipyard's "Location" Swayed Navy's Frigate Award' posted to the *Defense One* site – defenseone.com – on 25 June 2020.

10. The congressional authorisation for the new ships has caused something of a dispute with the navy. The latter's FY2021 budget submission continued to show the LPD as being acquired in line with the previous schedule, whilst the LHA procurement was shown as being advanced from FY2024 to FY2023. The reallocation of funding away the amphibious assault ship and fast transport to help pay for the border wall has only served to add fuel to the fire. In April and June 2020, the navy awarded HII substantial advanced procurement contracts for LHA-9, suggesting Congress may get its way in accelerating production of that ship. The position with respect to T-EPF-15 is less clear.

11. See David H Berger, *38th Commandant's Planning Guidance* (Washington, D.C.: USMC, 2019). For further discussion of the future direction of the US Navy amphibious force, see also Chapter 3.1.

12. See further Anthony Capaccio, 'Delays on $161 Billion Virginia-Class Subs Reaches 15 Months' posted to the *Bloomberg* website – www.bloomberg.com – on 28 February 2020.

13. For example, see Jesse Johnson, 'Three U.S. aircraft carriers operating on doorstep of South China Sea' posted to *The Japan Times* website – www.japantimes.co.jp – on 21 June 2020.

14. Analysis of the importance of the *Bertholf* and *Stratton* deployments, as well as the US Coast Guard's increasing focus on the Arctic is provided by Michael Faby in Briefing US Coast Guard operations: Extended horizons, *Jane's Defence Weekly* – 29 April 2020 (Coulsdon: Janes Group UK, 2020), pp.24–9.

15. Along with official navy websites, the Spanish-language infodefensa.com and its rival defensa.com remain invaluable sources of information on naval developments in Central and South America.

16. This section continues to benefit from the ongoing coverage of the Brazilian Navy in the Portuguese-language *Poder Naval* website at: naval.com.br/blog/

17. The *Inhaúma* class corvette *Jaceguai* was officially decommissioned in September 2019 but the planned disposal of the non-operational ship had been announced earlier. The frigates *Constituição* and *Liberal* are also reportedly in poor condition.

18. See *Plan de Desarrollo Naval 2042* (Bogotá: Armada de Colombia, 2020) available in Spanish by searching the navy's website at: www.armada.mil.co. In at least one area, the plan represents a lowering of the navy's previous ambitions, seeking five new frigates compared with previous plans for as many as eight.

19. It is noteworthy that Navantia's recent construction has suffered from a run of bad luck. In addition to the loss of *Naiguatá*, the slightly larger Venezuelan POVZEE type corvette *Warao* ordered under the same construction programme was severely damaged by grounding in 2012 and may not be repairable. The Royal Norwegian Navy *Fridtjof Nansen* class frigate *Helge Ingstad* sank in shallow water after a collision in November 2018. Although recovered, she was declared a constructive total loss.

2.2 REGIONAL REVIEW

ASIA AND THE PACIFIC

Author:
Conrad Waters

The steady expansion of China's People's Liberation Army Navy (PLAN) capacity has undoubtedly become the most significant recent influence on wider naval developments across the globe. Indeed, high-profile stories such as the refurbishment of the former Soviet *Varyag* to become China's first operational aircraft carrier, *Liaoning*, have attracted widespread public attention. Much of this publicity has arguably acted as a distraction to the key underlying story of the navy's development of effective anti-access/area denial (A2/AD) capabilities across China's 'near seas' and into the western Pacific. Ships such as the diminutive Type 056 and Type 056A series of 'Jiangdao' corvettes – over fifty of which are now in service – have played a much more important part of this stage in the PLAN's transformation than its larger vessels.

A series of recent events have, however, demonstrated that the PLAN is now entering another phase of its development. This is seeing the navy expand from largely A2/AD defence to a posture that also encompasses significant 'blue water' expeditionary capabilities. This shift in emphasis has formed part of the navy's strategic planning for a decade and more and was heralded, for example, by the anti-piracy deployments to the Gulf of Aden that were launched at the end of 2008.[1] However, the PLAN is now acquiring the tangible means with which to accelerate its global ambitions.

Emblematic of the PLAN's expanding blue water capacity was the formal commissioning of the new indigenous Type 002 aircraft carrier *Shandong* at the Sanya naval base on Hainan Island on 17 December 2019. The importance of the event was demonstrated by the presence of Chinese President Xi Jinping at the celebrations. The first aircraft carrier to be built from the keel-up in Asia since the end of the Second World War, her arrival makes China only one of three countries in the world to operate more than one full-sized carrier. With further, larger aircraft carriers reportedly under construction, there can be no doubt that the PLAN sees organic naval aviation as a key part of its future.[2]

Shandong's commissioning is, however, just one piece in the jigsaw. The last year has also confirmed the imminent arrival of a new expeditionary capability in the form of the long-rumoured Type 075 amphibious assault ship. Two of these LHD-type vessels have now been launched by Shanghai's Hudong-Zhonghua shipyard and it seems likely both will be in service before the end of 2021. In addition to substantially increasing China's ability to project military influence across the globe, they would also have a significant influence on any operation launched to forcibly reunite Taiwan with the rest of China. Additional Type 071 'Yuzhao' class amphibious transport docks are also in the course of completion.

However, possibly the most material Chinese naval development is the vast number of large surface combatants that are currently under construction. Whilst precise information is sometimes lacking, it seems that six of the c. 12,000-ton Type 055 'Renai' class destroyers and perhaps a dozen of the somewhat smaller Type 052 'Luyang III' class are currently either fitting out or undergoing trials. All will be in service before the end of 2022, on their own producing a more than 50 percent increase in PLAN destroyer strength. By contrast, the pace of orders for smaller frigates and corvettes appears to be slowing. All of this suggests a growing emphasis on operating 'high end' warships capable of distant expeditionary deployment, a doubtless uncomfortable prospect for China's rivals in the region and beyond.

One country certainly nervous of Chinese intentions is Japan. Mindful also of North Korea's weapons programmes, its recent defence strategy has also placed increasing emphasis on higher-end warfighting systems, including deployment of its own aircraft carriers and expansion of missile defence capabilities. A key plank in the latter approach was purchase of two Aegis Ashore land-based ballistic missile defence systems to improve the Japanese homeland's protection, a decision approved by Japan's cabinet in December 2017. However, in June 2020, the plan was abandoned over concerns that spent boosters from Standard Missile 3 interceptors could land on local communities. In the short term, the change of heart will place additional pressure on Japan's flotilla of Aegis-equipped destroyers, recently boosted to seven vessels with the commissioning of the new *Maya* on 19 March 2020. However, some suggest that Japan's longer-term solution might be to place greater emphasis on pre-emptive strike capabilities, a direction of travel that would be unlikely to reduce regional tensions.

The first indigenously-built Chinese aircraft carrier *Shandong* pictured during her commissioning ceremony at the Sanya naval base on Hainan Island on 17 December 2019. She represents one more piece in the jigsaw of China's rise to becoming a 'blue water' naval power. *(Feng Kaixuan/China Military Online)*

Table 2.2.1: FLEET STRENGTHS IN ASIA AND THE PACIFIC – LARGER NAVIES (MID 2020)

COUNTRY	AUSTRALIA	CHINA	INDONESIA	JAPAN	S KOREA	SINGAPORE	TAIWAN	THAILAND
Aircraft Carrier (CV)	–	2	–	–	–	–	–	–
Support/Helicopter Carrier (CVS/CVH)	–	–	–	4	–	–	–	1
Strategic Missile Submarine (SSBN)	–	7	–	–	–	–	–	–
Attack Submarine (SSN)	–	9	–	–	–	–	–	–
Patrol Submarine (SSK/SS)	6	50	4	20	18	4	4	–
Fleet Escort (DDG/FFG)	11	70	7	38	23	6	26	8
Patrol Escort/Corvette (FFG/FSG/FS)	–	60	24	6	12	14	1	11
Missile Armed Attack Craft (PGG/PTG)	–	75	21	6	18	–	c.30	6
Mine Countermeasures Vessel (MCMV)	4	25	10	21	9	4	10	6
Major Amphibious Units (LHD/LPD/LSD)	3	6	6	3	1	4	1	1

Notes: Chinese numbers approximate; Some additional Indonesian patrol gunboats are able to ship missiles; South Korean fleet escorts include thirteen deployed in littoral warfare roles; Taiwan's submarines are reported to have limited operational availability.

MAJOR REGIONAL POWERS – AUSTRALIA

The Royal Australian Navy is currently at something of a transitional stage with respect to its warship construction activities. Whilst a number of existing projects are now close to being successfully concluded, it will be some time before the next tranche of programmes ramp up to full production.

Current fleet structure is summarised in Table 2.2.2. In November 2019 it was announced that the two *Canberra* class LHDs had achieved final operational capability, completing the renewal of the RAN's amphibious capacity. The ships form a central part of the navy's desire to conduct sustained, integrated operations as components of joint forces that has been outlined in the 'Plan Pelorus' strategy. They also provide a useful spectrum of secondary capabilities, most recently evidenced by *Adelaide*'s deployment to assist the response to Australia's early 2020 bushfires.

Another important development occurred on 28 February 2020 when the third and final *Hobart class* air-defence destroyer – *Sydney* – was delivered by the Air Warfare Destroyer Alliance. She was formally commissioned during a ceremony conducted off the coast of New South Wales on Monday, 18 May 2020, bringing a lengthy and often troubled project to a close. Her arrival counterbalanced the withdrawal of the final *Adelaide* class frigate *Melbourne*, which was formally decommissioned in Sydney on 26 October 2019. Along with her sister *Newcastle*, she has been sold for further service in Chile.

In with the new ... The third and final Australian *Hobart* class air-defence destroyer *Sydney* pictured with the amphibious assault ship *Adelaide* at the time of the destroyer's at-sea commissioning ceremony on 18 May 2020. Both ships are the fruits of defence decisions the Australian government took two decades ago. *(Royal Australian Navy)*

Both the amphibious assault ship and destroyer projects trace their origins to Australia's 2000 Defence White Paper – *Defence 2000: Our Future Defence Force* – providing some indication of just how long it can take to bring sophisticated new capabilities into service.[3] This reality is also reflected

And out with the old ... The frigate *Melbourne* enters Sydney for the last time in September 2019 prior to her formal decommissioning ceremony the following month. Along with her sister *Newcastle* she was subsequently sold for further service with Chile. *(Royal Australian Navy)*

Table 2.2.2: ROYAL AUSTRALIAN NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Frigate – FFG	**HOBART** (F-100)	3	6,300 tons	147m x 19m x 5m	CODOG, 28 knots	200	2017
Frigate – FFG	**ANZAC**	8	3,600 tons	118m x 15m x 4m	CODOG, 28 knots	175	1996
Submarines							
Submarine – SSK	**COLLINS**	6	3,400 tons	78m x 8m x 7m	Diesel-electric, 20 knots	45	1996
Major Amphibious Units							
Amph Assault Ship – LHD	**CANBERRA** (JUAN CARLOS I)	2	27,100 tons	231m x 32m x 7m	IEP, 21 knots	290	2014
Landing Ship Dock – LSD	**CHOULES** (LARGS BAY)	1	16,200 tons	176m x 26m x 6m	Diesel-electric, 18 knots	160	2006

in the new construction programmes that are currently slowly moving towards implementation. The most important – and expensive – is the SEA 1000 programme for twelve new *Attack* class submarines. Following the outcome of a competition announced in April 2016, they are to be built to French Naval Group's 'Shortfin Barracuda' design by the company's Naval Group Australia subsidiary at Osborne in South Australia. The aim is to construct the submarines in a series of batches – each incorporating the latest technological innovations – to ensure the class remains 'regionally superior' throughout its life. Design work for the first batch of new boats is currently progressing under a contract agreed with the French company in March 2019. However, recent reports suggest that actual fabrication will not commence until 2024. An Australian National Audit Office report on the programme published in January 2020 stated that the design process is taking longer than initially anticipated, albeit there is as yet no change to scheduled delivery of the first submarine in the mid-2030s. More broadly, there is continued concern over the cost and technical risks inherent in delivering a bespoke submarine design that is now estimated to carry an acquisition price tag of as much as AU$80bn (US$60bn) over a more than 25-year construction period.[4]

Slightly closer to realisation is the SEA 5000 programme for nine *Hunter* class frigates. Variants of the British Royal Navy Type 26 Global Combat Ship, they are also to be constructed at Osborne. Their completion has been entrusted to BAE Systems, which has acquired control of the former shipbuilding division of state-owned ASC for the duration of the contract. Probably reflecting the greater maturity of the Type 26 design, work on the lead ship is expected to commence in December 2022 to achieve a planned 2027 delivery. In similar fashion to plans for the submarines, a number of prototype blocks will be fabricated before construction of the first frigate begins to ensure facilities, processes and the workforce are all operating efficiently.

The gap between completion of *Sydney* and commencement of work on *Hunter* is being bridged by the allocation of construction of the lead pair of SEA 1180 Phase 1 programme *Arafura* class offshore patrol vessels to the Osborne complex. Displacing around 1,600 tons, the new ships are based on Lürssen's OPV80 design. They will provide larger, 'longer-legged' replacements for the thirteen existing *Armidale* class patrol boats. Work on both *Arafura* and her sister *Eyre* is well underway following the latter's keel laying ceremony on 9 April 2020. A further ten members of the class will be completed in Henderson, Western Australia under the auspices of a joint venture between the vessel's German

A picture of *Cape St George*, the lead 'Cape' class vessel operated by the Australian Border Force. Her similarity to the Royal Australian Navy's *Armidale* class is apparent. Two of these vessels have been loaned to the navy, which will acquire six more in a surprise order announced in May 2020. *(Austal)*

designer and local company Cimvec. Work has already commenced – ahead of schedule – on *Pilbara*, the first Henderson-built ship.

Austal, another Western Australian-based company that was hoping for a role in the *Arafura* class programme, has recently been thrown something of a lifeline in the form or an additional order for six of its c. 300-ton 'Cape' class patrol vessels. The design is already in navy and border force use. Announced on 1 May 2020, the unexpected contract – described as providing an important economic stimulus and employment continuity during the COVID-19 pandemic – has seemingly been driven by political considerations. However, the new ships are close in configuration to the existing Austal-built *Armidale*s. They should therefore provide a useful complement to the larger *Arafura*s.

Away from Australia, construction of the two new *Supply* class replenishment oilers allocated to Navantia's north-west Spanish yard in Ferrol under Project SEA 1654 Phase 3 is progressing well. The lead ship is scheduled to begin sea trials in August 2020 whilst her sister, *Stalwart*, was launched on 30 August 2019.

MAJOR REGIONAL POWERS – CHINA

As already discussed in the introduction to this chapter, China's naval expansion has become a matter of global interest. This is particularly the case in the United States, where the PLAN is increasingly viewed as being able to challenge the US Navy's ability to maintain wartime control over the blue water areas of the Western Pacific. In May 2020 a series of alarmist articles quoting unattributed 'American defence sources' appeared in Britain's *The Times* and other papers stating Pentagon war games focusing on the year 2030 concluded the United States would lose any war fought in the Pacific with China.[5]

Part of the inspiration of these stories may have been the release of an unclassified, February 2020 US Office of Naval Intelligence (ONI) briefing comparing PLAN and US Navy shipbuilding plans in the decade to 2030.[6] Some of the report's key findings are summarised in Table 2.2.3. It can be seen that China steadily surpassed the US Navy in its ability to field 'battleforce' ships in the period between 2010 and 2020. Moreover, this lead is likely to grow over the next decade if the 355-strong US Navy fleet target contained in the 2016 Force Structure Assessment remains unchanged. The US Navy's ships still tend to be larger and technologically more capable than their PLAN counterparts. However, the ONI concludes that Chinese ship design and material quality is in many cases comparable to the US Navy's warships and that China is quickly closing the gap in any areas of deficiency.

A somewhat more granular summary of the PLAN's current strength is provided in Table 2.2.4. Whilst this differs in detail from the figures contained in the ONI briefing, the overall picture it provides is similar. Variations relate primarily to different assessments on the precise timings of warship deliveries and decommissionings, as well as uncertainty over the operational status of some older vessels. More detailed analysis of different warship types follows below.

Aircraft Carriers and Amphibious Ships: Although the commissioning of *Shandong* marks a major step forward in the PLAN's carrier ambitions, development of an effective aircraft carrier capability remains work in progress. The Shenyang J-15 strike fighter that forms the fixed-wing complement of both carriers is based on the 1980s-era Russian Sukhoi Su-33 and has earned a decidedly mixed reputation in Chinese service. Sources on the number of J-15s delivered to the PLAN Air Force vary from between twenty-four to as many as fifty, with at least two lost in accidents to date. Even accepting higher production estimates, the number of jets available is a bare minimum to sustain operations from both 'flat tops'.

One complicating factor is the PLAN's widely-assumed desire to move from the short take-off but arrested recovery (STOBAR) technology used in its first two carriers to catapult-launched systems in subsequent ships. This will require procurement of a new design of carrier jet. Next-generation aircraft – notably naval variants of the Shenyang FC-31 and Chengdu J-20 stealth fighters – are said to be competing for the contract but it will be some years before the programme is realised.[7] The first Type 003 carrier destined to operate the new jets has been under construction at the Jiangnang Shipyard in Shanghai since around 2017. Satellite imagery suggests that sufficient progress has been made with construction to allow launch before the end of 2021. At least two Type 003 carriers are reportedly planned. Estimated to displace around 80,000 tons, they will be conventionally powered but likely equipped with electromagnetic catapults.

Longstanding rumours of PLAN amphibious helicopter carrier construction were confirmed in

Table 2.2.3: CHINA PLAN EXPANSION: 2000-2030

'BATTLEFORCE SHIPS'[1]

YEAR	2000	2005	2010	2015	2020	2025	2030
Strategic Submarine (SSBN)	1	1	3	4	4	6	8
Attack Submarine (SSN)	5	4	5	6	7	10	13
Patrol Submarine (SSK/SS)	56	56	48	53	55	55	55
Major Surface Combatants (CV/DDG)	19	25	25	26	43	55	65
Other Surface Combatants (FFG/FF)	38	43	50	74	102	120	135
Other	-9[2]	91	89	92	149	154	149
PLAN Total	**110**[2]	**220**	**220**	**255**	**360**	**400**	**425**
US Navy Comparable[3]	**318**	**282**	**288**	**271**	**297**	**N/A**[3]	**N/A**[3]

Notes:

1. Data is based on CRS report *RL33153: China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, which itself draws on unclassified ONI data provided in a report to the US Senate Armed Services Committee in February 2020. The 'Battleforce' designation is based on US Navy counting rules and excludes many non-blue water combatants, notably the PLAN's large number of missile-armed fast attack craft. No account is taken of the qualities of individual combatants.

2. The 'other' line has been derived by subtracting ONI data on specific ship types from their total figure for the year in question. There is a clear discrepancy with respect to 2000, where the 'PLAN Total' figure would seem to be in error.

3. This data is based on historic US Navy fiscal year end numbers. US fleet numbers are targeted to increase to 355 vessels under the 2016 Force Structure Assessment (FSA) but this is currently being revised. The 355 target is a long-term ambition, with fleet size likely to be 313 vessels in 2025 and 331 in 2030 on the latest available data.

mid-2019 when the constituent modules of the first Type 075 LHD began to form a cohesive whole at the Hudong-Zhonghua yard in Shanghai. The vessel was launched on 25 September 2019 and was quickly followed by a sister on 22 April 2020. Both are likely to enter service in 2021. The new ships are broadly similar in size to the Italian *Trieste* but have a conventional single island and aviation facilities that are focused purely on helicopter operations. Their aft well deck is compatible with the LCAC-like Type 726 hovercraft also deployed in the Type 071 'Yuzhao' class amphibious transport docks. What appears to be the final two PLAN members of the latter eight-strong class – all also built by Hudong-Zhonghua – were performing sea trials as of mid-2020.

Surface Combatants: In line with the PLAN's recent focus on high-end surface combatants, current surface warship construction is dominated by series production of Type 052D 'Luyang III' and Type 055 'Renai' class destroyers. The former design traces its origins to the Type 052B and Type 052C 'Luyang I' and 'Luyang II' classes that first entered service in 2004–05 and which have subsequently been subject to progressive revision. This trend continued in 2020 with the commissioning of *Zibo* – the 14th member of the overall Type 052D class but the first of a new stretched variant – on 12 January. Compared with her earlier sisters, her flight deck has been extended by some 4m to accommodate the naval version of the Harbin Z-20 helicopter. There are also changes to the hangar superstructure and installation of a revised surveillance radar. At least eleven additional Type 052Ds are in the course of assembly. Construction is split between the Jiangnang and Dalian yards on a roughly 2/1 basis.

January 2020 also saw the formal commissioning of the first large Type 055 'Renai' class destroyer, *Nanchang*. As she had previously participated in the PLAN's 70th anniversary fleet review in May 2019 and subsequently operated with the carrier *Liaoning*, the delay in her official entry into service is a little surprising. The Type 055s have much the same equipment as that found on the Type 052D design. However, they have a significantly greater number of VLS cells (112 compared to 64) and benefit from COGAG propulsion. Western media reports speculate that they are largely intended to operate as

Table 2.2.4: PEOPLE'S LIBERATION ARMY NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CV	Type 001A (Modified Kuznetsov)	1	65,000 tons	315m x 35/75m x 10m	Steam, 32 knots	Unknown	2019
Aircraft Carrier – CV	Type 001 **LIAONING** (Kuznetsov)	1	60,000 tons	306m x 35/73m x 10m	Steam, 32 knots	Unknown	2012
Principal Surface Escorts							
Destroyer – DDG	Type 055 **NANCHANG** ('Renai')	1	c.12,000 tons	180m x 20m x 7m	COGAG, 30 knots	c.300	2019
Destroyer – DDG	Type 052D **KUNMING** ('Luyang III')	14	7,500 tons	156m x 17m x 6m	CODOG, 28 knots	280	2014
Destroyer – DDG	Type 051C **SHENYANG** ('Luzhou')	2	7,100 tons	155m x 17m x 6m	Steam, 29 knots	250	2006
Destroyer – DDG	Type 052C **LANZHOU** ('Luyang II')	6	7,000 tons	154m x 17m x 6m	CODOG, 28 knots	280	2005
Destroyer – DDG	Type 052B **GUANGZHOU** ('Luyang I')	2	6,500 tons	154m x 17m x 6m	CODOG, 29 knots	280	2004
Destroyer – DDG	Project 956E/EM **HANGZHOU** (Sovremenny)	4	8,000 tons	156m x 17m x 6m	Steam, 32 knots	300	1999
Destroyer – DDG	Type 051B **SHENZHEN** ('Luhai')	1	6,000 tons	154m x 16m x 6m	Steam, 31 knots	250	1998
Destroyer – DDG	Type 052 **HARBIN** ('Luhu')	2	4,800 tons	143m x 15m x 5m	CODOG, 31 knots	260	1994
Two obsolescent destroyers of the Type 051 **JINAN** ('Luda') class are due for imminent retirement.							
Frigate – FFG	Type 054A **XUZHOU** ('Jiangkai II')	30	4,100 tons	132m x 15m x 5m	CODAD, 28 knots	190	2008
Frigate – FFG	Type 054 **MA'ANSHAN** ('Jiangkai I')	2	4,000 tons	132m x 15m x 5m	CODAD, 28 knots	190	2005
Frigate – FFG	Type 053 H3 **LIANYUNGANG** ('Jiangwei II')	8	2,500 tons	112m x 12m x 5m	CODAD, 27 knots	170	1992
Frigate – FSG	Type 056/056A **BENGBU** ('Jiangdao')	55+	1,500 tons	89m x 12m x 4m	CODAD, 28 knots	60	2013
Plus c.5 remaining obsolescent frigates of the Type 053 H1/H1G **TAIZHOU/BEIHAI** ('Jianghu II & V') classes that are being steadily retired.							
Submarines							
Submarine – SSBN	Type 094/094A ('Jin')	c.6	9,000 tons	133m x 11m x 8m	Nuclear, 20+ knots	Unknown	2008
Submarine – SSBN	Type 092 ('Xia')	1	6,500 tons	120m x 10m x 8m	Nuclear, 22 knots	140	1987
Submarine – SSN	Type 093/093A ('Shang')	c.6	6,000 tons	107m x 11m x 8m	Nuclear, 30 knots	100	2006
Submarine – SSN	Type 091 ('Han')	3	5,500 tons	106m x 10m x 7m	Nuclear, 25 knots	75	1974
Submarine – SSK	Type 039A/039B (Type 041 'Yuan')	12+	2,500 tons	75m x 8m x 5m	AIP, 20+ knots	Unknown	2006
Submarine – SSK	Type 039/039G ('Song')	13	2,300 tons	75m x 8m x 5m	Diesel-electric, 22 knots	60	1999
Submarine – SSK	Project 877 EKM/636 ('Kilo')	12	3,000 tons	73m x 10m x 7m	Diesel-electric, 20 knots	55	1995
Plus c.15 obsolescent patrol submarines of the Type 035 ('Ming' class). A Type 032 'Qing' trials submarine has also been commissioned for strategic missile trials.							
Major Amphibious Units							
Landing Platform Dock	Type 071 **KULUN SHAN** ('Yuzhao')	6	18,000 tons	210m x 27m x 7m	CODAD, 20 knots	Unknown	2007

specialised escorts to the carrier forces. A further seven members of the class have been started to date, with the Jiangnang and Dalian Shipyards sharing production on an equal basis.

Production of the Type 054A 'Jiangkai II' frigates for PLAN service appeared to have concluded when the 30th member of the class, *Zaozhuang*, was commissioned on 22 February 2019. However, with overseas transfers of legacy designs now extending to the 1990s-era Type 053 H3 'Jiangwei II' there may be a need for more intermediate combatants and there have been some rumours of a further, modified batch. Meanwhile deliveries of the smaller Type 056A littoral corvettes have continued at some pace over the past year. Perhaps as many as sixty of the Type 056/56A series are now in service. However, there have been reports that *Aba* – launched at the Huangpu yard in Guangzhou on 30 December 2019 – will be the last of the class. This would take total production for PLAN service to seventy-two units. A further six C-13B and P18-N derivatives have been exported to Bangladesh and Nigeria.

Submarines: Analysis of China's underwater forces remains subject to some speculation given lack of official transparency and limited news flow. Recent analysis seemingly confirms previous assessments of construction of a pair of modified Type 094A strategic submarines, both of which are now reportedly in commission. They join the four existing Type 094 'Jin' class boats to give the PLAN a flotilla of six modern ballistic missile-armed submarines. This total is seemingly matched by the six Type 093/093A 'Shang' class nuclear-powered attack submarines delivered in two batches from 2006 onwards. Although earlier-generation nuclear-powered boats of the Type 091 and Type 092 classes remain in the inventory, these are now probably of marginal operational value. Analysis of satellite imagery of the Bohai shipyard at Huludao that is the focal point of Chinese nuclear submarine construction reveals considerable work on new facilities.[8] These will probably be used for the long-anticipated third generation Type 095 attack and Type 096 strategic submarines. The new designs are likely to be larger and acoustically stealthier than the existing nuclear-powered flotilla, closing the technological gap with equivalent US Navy boats. A new, longer-range JL-3 submarine-launched ballistic missile remains under development for deployment in the Type 096 class boats

There has been little news of the PLAN's conventionally-powered submarine force. Its operational element is generally believed to comprise two, eight-strong flotillas in each of China's three fleets to give a requirement for forty-eight boats plus additional training assets. A proportion of this force is comprised of legacy Type 053 'Ming' class submarines but there has been little tangible news of further production of the latest Type 039A/Type 041 'Song' class boats to complete their replacement. Whilst it is quite possible that additional 'Songs' have been completed to add to the dozen or more currently in commission, it might also be the case that production has been slowed or even halted pending development of more advanced technology. Much capacity at the Wuchang yard in Wuhan that – alongside Shanghai's Jiangnang facility – is the focal point of China's conventional submarine production is currently taken up with completing export programmes for Pakistan and Thailand, making any pause in domestic activity more acceptable.

Other Developments: The continued induction of large numbers of front-line combatants into the PLAN invariably grabs most column inches. However, the country's shipbuilding sector is increasingly demonstrating a capacity for innovation that matches developments in the 'West'. Illustrative of this focus were two news stories towards the end of 2019 reporting the sighting of a small 'finless' ('sailless') submarine at the Jiangnang yard and the development of a new high speed, multi-role unmanned surface vessel (USV) by the Jiangsu Automation Research Institute.[9] The latter vessel is a c. 20-ton catamaran-hulled vessel capable of operating at 42 knots on waterjet propulsion and designed to ship a range of modular weapons and sonars for true multi-mission functionality. Both vessels are indicative of China's understanding of the need to achieve a qualitative – as well as quantitative – advantage over potential rivals, a fact also reflected in ONI's report.

The imperative to pursue innovation and technological strength was also cited as one of the key factors driving the merger of China's two main state-owned shipbuilding groups – the Chia Shipbuilding Industry Corporation (CSIC) and the China State Shipbuilding Corporation (CSSC) – into the unified China Shipbuilding Corporation (CSC) on 27 November 2019. The merger represents a reversal

Xingyang is one of the series of diminutive Type 056 and Type 056A littoral corvettes delivered to the fleet in very large numbers by four separate Chinese shipyards from early 2013 onwards. With over seventy of the series now launched, it appears that production is drawing to a close. *(Wang Guangjie/China Military Online)*

of the previous policy that saw the split of the industry into two competing groups at the end of the 1990s and also reflects a desire to increase efficiency and develop a more coordinated approach to export markets. The merged company will be the world's largest shipbuilding enterprise. Its headline statistics include assets of c. US$110bn, annual sales approaching US$80bn and over 300,000 employees.

MAJOR REGIONAL POWERS – JAPAN

Japan Maritime Self Defence Force (JMSDF) structure and procurement are currently governed by two major policy and planning documents – the *National Defense Program Guidelines for FY2019* and beyond and the *Medium Term Defense Program* (FY2019-FY2023) – published in December 2018.[8] These essentially maintained previous plans to expand the navy's force structure to a total of twenty-two submarines and fifty-four major surface combatants. The latter figure includes four carrier-like DDH 'helicopter-carrying destroyers' and eight Aegis-equipped air-defence ships. However, a significant change to past policy involves modifying the navy's two larger, *Izumo* class DDHs for F-35B Lightning II strike fighter operation. This will essentially give Japan her first aircraft carriers since the Second World War.

Japan's 2020 defence budget continues implementation of these plans.[9] Warship construction includes two additional small 3,900-ton surface escorts – the fifth and sixth members of the class – at a unit cost of 47.2bn Japanese yen (c. US$450m). Originally known as the 30DD or DX class, these now seem to be officially referred to as 30FFM multi-mission frigates. Further provision is also made for life extensions to existing surface combatants to help achieve the 54-ship target. A similar approach is taken with respect to the submarine flotilla. Here, a 70.2bn yen (c. US$650m) allocation for the third new 3,000-ton boat is supplemented by modest provisions for further modernisation of existing classes. There is also 12.6bn yen (c. US$120m) for a fourth *Awaji* class minesweeper. However, possibly the most significant procurement decisions were funding of an initial batch of six F-35B aircraft for 79.3bn yen (C. US$750m) and provision for the start of work on *Izumo* to allow their deployment at sea.

For the time being, current fleet composition is set out in Table 2.2.5. The JMSDF was boosted by two significant deliveries in March 2020. One was that of the new destroyer *Maya* (DDG-179), which was commissioned on 19 March. The latest iteration of a series of Aegis-equipped JMSDF destroyers, she is longer and heavier than the previous *Atago* (DDG-177) class and seemingly incorporates incremental improvements to radar-cross section reduction. More importantly, she adopts the acoustically stealthy combined gas-electric and gas (COGLAG) propulsion system introduced in the *Asahi* (DD-119) class ships. She is also configured to undertake the theatre ballistic missile defence (TBMD) role from build and is equipped with US Navy-compatible cooperative engagement capability. A sister, *Haguro* (DDG-180), is currently undergoing trials and will be delivered early in 2021 to meet the navy's target of fielding eight Aegis-equipped ships. The two ships will replace the 1980s-era *Hatakaze* (DDG-171) class destroyers, with *Hatakaze* herself now assigned to the training role.

Two weeks earlier, on 5 March 2020, *Oryu* – the JMSDF's 11th *Soryu* class submarine – was delivered at Mitsubishi Heavy Industries' Kobe facility, subsequently joining Submarine Squadron 3 of the JMSDF's 1st Submarine Flotilla at Kure.

Table 2.2.5: JAPAN MARITIME SELF-DEFENCE FORCE: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Support and Helicopter Carriers							
Helicopter Carrier – DDH	**IZUMO** (DDH-183)	2	27,000 tons	248m x 38m x 7m	COGAG, 30 knots	470	2015
Helicopter Carrier – DDH	**HYUGA** (DDH-181)	2	19,000 tons	197m x 33m x 7m	COGAG, 30 knots	340	2009
Principal Surface Escorts							
Destroyer – DDG	**MAYA** (DDG-179)	1	10,500 tons	170m x 21m x 6m	COGLAG, 30 knots	300	2020
Destroyer – DDG	**ATAGO** (DDG-177)	2	10,000 tons	165m x 21m x 6m	COGAG, 30 knots	300	2007
Destroyer – DDG	**KONGOU** (DDG-173)	4	9,500 tons	161m x 21m x 6m	COGAG, 30 knots	300	1993
Destroyer – DDG	**HATAKAZE** (DDG-171)	1 (1)	6,300 tons	150m x 16m x 5m	COGAG, 30 knots	260	1986
Destroyer – DDG	**ASAHI** (DD-119)	2	6,800 tons	151m x 18m x 5m	COGLAG, 30 knots	230	2017
Destroyer – DD	**AKIZUKI** (DD-115)	4	6,800 tons	151m x 18m x 5m	COGAG, 30 Knots	200	2012
Destroyer – DDG	**TAKANAMI** (DD-110)	5	6,300 tons	151m x 17m x 5m	COGAG, 30 knots	175	2003
Destroyer – DDG	**MURASAME** (DD-101)	9	6,200 tons	151m x 17m x 5m	COGAG, 30 knots	165	1996
Destroyer – DDG	**ASAGIRI** (DD-151)	8	4,900 tons	137m x 15m x 5m	COGAG, 30 knots	220	1988
Destroyer – DDG	**HATSUYUKI** (DD-122)	2 (2)	3,800 tons	130m x 14m x 4m	COGOG, 30 knots	200	1982
Frigate – FFG	**ABUKUMA** (DE-229)	6	2,500 tons	109m x 13m x 4m	CODOG, 27 knots	120	1989
Submarines							
Submarine – SSK	**SORYU** (SS-501)	11	4,200 tons	84m x 9m x 8m	AIP, 20 knots+	65	2009
Submarine – SSK	**OYASHIO** (SS-590)	9 (2)	4,000 tons	82m x 9m x 8m	Diesel-electric, 20 knots+	70	1998
Major Amphibious Units							
Landing Platform Dock – LPD	**OSUMI** (LST-4001)	3	14,000 tons	178m x 26m x 6m	Diesel, 22 knots	135	1998

Note: Figures in brackets refer to trials or training ships.

The JMSDF's *Maya* is the latest iteration of a series of Aegis-equipped destroyers delivered from the mid-1990s onwards. Commissioned in March 2020, she is the first Japanese warship to be equipped with cooperative engagement capability. *(JMSDF)*

In contrast to the previous ten members of the class, which use lead-acid batteries, she is equipped with lithium-ion (Li-on) batteries for energy storage. Supplied by G S Yuasa, the batteries are reported to store twice the amount of power as previous types, extending underwater endurance without the need to resort to supplementary systems such as air-independent propulsion (AIP). Another Li-on powered member of the class, *Toryu*, has been launched by Kawasaki Heavy Industries. Subsequent production will then shift to the new 3,000 ton 29SS design. These will be delivered at the rate of one unit p.a. from 2022 onwards.

MAJOR REGIONAL POWERS – SOUTH KOREA

Although the Republic of Korea's defence budget faces temporary headwinds as a result of the COVID-19 crisis, its underlying trajectory shows a significant upward trend. The Korean Ministry of Defence's annual mid-term defence plan for the period 2020–4 published in August 2019 envisages expenditure increases averaging around 7 percent p.a. over the five-year period, continuing a recent trend of material growth. There is also a greater emphasis on capital procurement within the overall total spend. Whilst the threat from North Korea and uncertainty over the strength of the American alliance are undoubtedly key factors driving this largesse, a desire to play a greater part on the world stage also seems to be an influence. Rivalry with neighbouring Japan – exacerbated by the legacy of the Second World War – is another consideration. The fact that China's PLAN was invited to participate in the JMSDF's October 2019 multinational fleet review but that Japan deemed the environment was not 'adequate' to solicit Republic of Korean Navy attendance provides an interesting insight into the current state of affairs.

Given that South Korea has one of the world's largest shipbuilding industries and increasingly advanced technological capabilities, it is well placed to support a major fleet expansion. This is reflected in the significant number of naval programmes that are currently underway. Modernisation of the surface fleet essentially has two strands. One is built around the KDX series of destroyers. Current attention is focused on construction of a second, modified batch of three KDX-III class ships. Aegis-equipped vessels derived from the US Navy's *Arleigh Burke* (DDG-51) class design, this second batch will be slightly enlarged in similar fashion to the approach adopted by Japan in transitioning from the *Atago* to *Maya* classes. In contrast to the first KDX-III trio, they will also likely be equipped with a TBMD capability. The first of the class will be delivered by November 2024 – a year or so later than initially envisaged – under a contract with Hyundai Heavy Industries (HHI) signed in October 2019. The other two vessels will follow in 2026 and 2028. Attention will then shift to a new, next-generation KDDX design. This is currently subject to a basic design competition. Current plans envisage a firm order for the first of the new ships being placed around 2024, with delivery before the end of the decade.

The smaller counterparts of the KDX destroyers are the FFX series of frigates. These are more suitable for littoral operations than the bigger destroyers but are also sufficiently large for extended deployment. A total of twenty is planned in three batches of six, eight and six. Current construction is focused on the FFX-II batch, also known as the *Daegu* class after the lead ship that was commissioned in March 2018. All eight of these have now been ordered, with the third and fourth vessels – respectively named *Seoul* and *Donghae* – launched by HHI on 11 November 2019 and 29 April 2020. In March 2020 it was announced that HHI has also been awarded the detailed design and build contract for the first of the FFX-III design iteration, which will be named *Ulsan.* The new variant will see a further increase in size over the FFX-II and will reportedly include an advanced multi-function radar and a hybrid electric and gas propulsion system. This may refer to a COGLAG arrangement similar to that employed by the JMSDF.

The new frigates replace the existing 1980s-era *Ulsan* and *Po Hang* classes, which are being withdrawn in increasing numbers. This is causing a temporary dip in second-line surface escorts, as illustrated by Table 2.2.6 summarising current fleet

strength. More positively, submarine numbers continue to grow. The eighth Type 214 submarine – *Lee Beom-seok* – built under the KSS-II programme was commissioned in May 2019. The ninth and final boat – *Shin Dol-seok* – has either recently been or is close to being inducted. Production has now transitioned to the indigenous KSS-III design, which will be built in three batches of three submarines each. The lead boat of the first batch – *Dosan Ahn Chang-Ho* – has been undergoing an exhaustive set of sea trials since June 2019 and is likely to commission within the next year. As the nine older Type 209 submarines that were built under the KSS-I programme are also currently undertaking a Performance Improvement Project (PIP) mid-life upgrade, it seems likely the navy's submarine flotilla will grow beyond the current eighteen units.

The Republic of Korea Navy's longer-term ambitions extend to the operation of nuclear-powered submarines and fixed-wing aircraft carriers. Plans for the latter are further advanced. The acquisition of a new amphibious assault ship specifically designed for short take-off and vertical landing (STOVL) aircraft was reportedly approved in July 2019 and subsequently confirmed in the 2020–4 defence plan. Although studies have been undertaken to assess the potential for converting the existing LHD *Dokdo* and her soon to be commissioned sister *Marado* for F-35B operation, it seems that the pair may be too small to operate the American aircraft effectively. On 16 October 2019 HHI announced it had been awarded a contract to undertake conceptual design

Two of the Republic of Korea Navy's FFX-I *Incheon* class frigates (foreground) pictured with one of the older *Po Hang* class corvettes they are replacing during exercises with the US Navy in April 2020. The inset is a graphic released by Hyundai Heavy Industries of the larger FFX-III frigate design, the first of which was ordered as *Ulsan* in March 2020. *(US Navy/Hyundai Heavy Industries)*

Table 2.2.6: REPUBLIC OF KOREA NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Destroyer – DDG	KDX-III **SEJONGDAEWANG-HAM**	3	10,000 tons	166m x 21m x 6m	COGAG, 30 knots	300	2008
Destroyer – DDG	KDX-II **CHUNGMUGONG YI SUN-SHIN**	6	5,500 tons	150m x 17m x 5m	CODOG, 30 knots	200	2003
Destroyer – DDG	KDX-I **GWANGGAETO-DAEWANG**	3	3,900 tons	135m x 14m x 4m	CODOG, 30 knots	170	1998
Frigate – FFG	FFX-2 **DAEGU**	1	3,600 tons	122m x 14m x 4m	CODLOG	140	2017
Frigate – FFG	FFX **INCHEON**	6	3,000 tons	114m x 14m x 4m	CODOG, 30 knots	140	2013
Frigate – FFG	**ULSAN**	4	2,300 tons	102m x 12m x 4m	CODOG, 35 knots	150	1981
Corvette – FSG	**POHANG**	12	1,200 tons	88m x 10m x 3m	CODOG, 32 knots	95	1984
Submarines							
Submarine – SSK	KSS-2 **SON WON-IL** (Type 214)	9	1,800 tons	65m x 6m x 6m	AIP, 20+ knots	30	2007
Submarine – SSK	KSS-1 **CHANG BOGO** (Type 209)	9	1,300 tons	56m x 6m x 6m	Diesel-electric, 22 knots	35	1993
Major Amphibious Units							
Amph Assault Ship – LHD	LPX **DOKDO**	1	18,900 tons	200m x 32m x 7m	Diesel, 22 knots	425	2007

studies for the new ship. Given the project is at such an early stage, however, it would seem likely to be well into the next decade before the navy's ambition is realised. The medium term defence plan also encompasses the procurement of specialised arsenal ships loaded with precision land attack missiles as part of a strategic pre-emptive strike response to North Korea's nuclear weapons programmes.

OTHER REGIONAL FLEETS

Indonesia: Indonesia's defence budget has been one of a number in the region to suffer from temporary COVID-19 reductions. However, reports suggest spending will rebound significantly in the current year as the country enters the third and final stage of its Minimum Essential Force (MEF) programme. Covering the period 2020–4, this phase is likely to see continued investment in naval modernisation as the country continues to face pressure from China's extensive maritime claims. In May 2020, Indonesia joined neighbouring countries in writing to the United Nations to reject China's 'nine-dash line' demarcation of the South China Sea, which it views as putting its own economic interests at risk.[12]

Naval strategy continues to be focused on creating a relatively small force of modern surface combatants and submarines to supplement a larger fleet of constabulary and amphibious shipping used to secure the vast archipelago. In February 2020, the navy completed combat-system installation in *I Gusti Ngurah Rai* – the second of two Damen 'Sigma' 10514 *Martadinata* class light frigates first commissioned in 2017–18. There are now a total of six 'Sigma' type vessels in active service. However, it seems that acquisition of the much larger Danish *Iver Huitfeldt* class design will drive the next stage of surface fleet modernisation, possibly reflecting a desire to acquire ships with the endurance to conduct extended EEZ patrols. The navy's old *Van Speijk/Leander* class frigates are also now beginning to pay off, commencing with the withdrawal of *Slamet Riyadi* in August 2019, providing another argument to acquire vessels larger than the diminutive 'Sigmas'.

There have also been reports of a potential change of heart with respect to submarine procurement. At the moment, the navy is close to inducting *Alugoro*, the last of three Type 209/1400 boats ordered from South Korea's DSME in 2011. Assembled by PT PAL in Indonesia, she is due to be followed by three similar submarines under a deal agreed in April 2019. When combined with the two existing modernised Type 209/1300 *Cakra* class boats, this would allow the navy to form a relatively homogenous, eight-strong flotilla. However, it is thought that Indonesia is now looking to terminate the deal in favour of newer, Turkish-built Type 214 submarines, which would have the benefit of auxiliary AIP.

The most modern Indonesian major surface combatant, *I Gusti Ngurah Rai* is the second of two Damen 'Sigma' 10514 light frigates assembled in Surabaya by local shipyard PT PAL. She completed weapons outfitting early in 2020. There are indications Indonesia is looking to the larger Danish *Iver Huitfeldt* class design for its next surface combatants. *(Damen)*

Meanwhile construction for the second-line fleet continues apace at local yards, amongst which PT PAL remains prominent. It delivered the fourth large KCR-60 *Sampari* class fast attack craft – *Kerambit* – on 27 July 2019 and laid the keels for two, improved iterations a few days later. At least two further ships are believed to be on contract and as many as eighteen may be planned. PT PAL is also working on another *Semarang* class variant of the *Makassar* amphibious transport dock design, which – like her sister – will also be laid out as a hospital ship. A total of six of these ships are now operated in LPD or hospital ship configurations, the latter seeing significant use as part of Indonesia's COVID-19 response. Presentations on the MEF 2020–4 plan suggest a target of at least ten of these flexible but relatively inexpensive ships.

Malaysia: The Malaysian government unveiled its first ever defence white paper in a parliamentary debate in December 2019, subsequently making copies available to a wider public.[13] Citing great power rivalry between the United States and China alongside 'complexities' in relations between ASEAN states and increasing non-traditional security threats as its main security challenges, it describes Malaysia as '… a maritime nation with continental roots …' and sets out a strategy based on the principles of non-alignment but partnership to achieve its security objectives. The document sets out the broad structure and capabilities required to ensure an effective defence but has been criticised for being light on specific details. Part of the problem remains a difficult funding backdrop that suggests the means required to implement the white paper's aims are unlikely to be forthcoming.

The navy's long-term focus remains on rationalising its current rather disparate collection of combatants into five main classes under its '15 to 5' transformation programme. These are (i) frigate-like littoral combat ships, (ii) corvette-like new generation patrol vessels, (iii) smaller, coastal littoral mission vessels, (iv) LHD-like multi-role support ships and (v) submarines. There has been mixed progress in achieving this aim in the last year. Positively, the first of up to eighteen littoral mission vessels has been delivered with the transfer of the Wuchang Shipbuilding-built *Keris* on 31 December 2019. Displacing around 700 tons, the 69m vessel is essentially a lightly-armed constabulary unit capable of operating rigid-hulled inflatable boats (RHIBs) and able to embark a containerised mission module. Three more ships have been ordered from China, with the second member of the class – *Sundang* – launched at Wuhan on 12 July 2019. Planned completion was April 2020. However, this has inevitably been impacted by the initial epicentre of the COVID-19 pandemic falling on the city where the ships are built.

Construction of an initial batch of six of the more complex littoral combat ships – being built by Boustead Naval Shipyard to a French Naval Group 'Gowind' design – is proving far more problematic. The first unit – named *Maharaja Lela* – was launched in August 2017 prior to expected delivery in 2019. Three additional units are at various stages of construction. However, the programme has been badly impacted by industrial problems reminiscent of the yard's previous difficulties fitting out the *Kedah* class new generation patrol vessels. Some reports suggest the lead ship's arrival is now anticipated in 2023, revealing the progress Malaysia still needs to make to deliver an efficient indigenous warship building capability.

The Royal New Zealand Navy took delivery of its largest-ever warship in 2020 following the completion of the 26,000-ton replenishment vessel *Aotearoa* by Hyundai Heavy Industries in South Korea. She arrived in Auckland, New Zealand on 26 June 2020. *(NZDF)*

New Zealand: The main naval event in New Zealand in the past year is undoubtedly delivery of the new replenishment vessel *Aotearoa.* Constructed by HHI in South Korea, the 26,000-ton vessel will be the largest ever operated by the Royal New Zealand Navy and will greatly expand its abilities to operate across the Southern Ocean in all weather conditions. She has been specifically designed to be able to operate in support of New Zealand's Antarctic bases. Accordingly, thicker, higher-grade steel has been used in her construction to allow summer and autumn operation in first-year ice in line with the Polar Class 6 classification society notation. She made her maiden arrival in Auckland on 26 June 2020. Achievement of full operational capability is scheduled for 2021.

Other recent developments have included the decommissioning of the inshore patrol vessels *Rotoiti* and *Pukaki* on 17 October 2019. Their withdrawal is in line with previous defence statements focusing on the greater utility of the navy's offshore patrol vessels. However, their limited ten years of service under the New Zealand flag seems poor value for money. More positively, the modernisation of the two *Anzac* class frigates in Canada is making good progress. *Te Kaha* is scheduled to return to sea in the second half of 2020 after completion of the major programme of weapons and combat systems upgrades.

North Korea: The Democratic People's Republic of Korea Navy operates a very large force of small and/or low technology submarines, fast attack craft and amphibious vessels. However, most attention inevitably focuses on those assets intended to support its nuclear weapons programme. Accordingly, there has been continued coverage of developments at the secret Sinpo South Shipyard. This is the facility where a second strategic submarine is believed to be under construction. Footage of North Korean leader Kim Jong Un visiting a new submarine under construction at an unspecified shipyard that was released in July 2019 suggests this may be a modified Type 033 'Romeo' class boat with space for three submarine-launched ballistic missiles. However, ongoing satellite imagery of Sinpo has yet to reveal the new vessel in the water. Meanwhile, on 2 October 2019, North Korea conducted an underwater launch of its new Pukguksong-3 (KN-26) submarine-launched ballistic missile (SLBM) off the coast of Wonsan. This appears to be an extended range variant of the existing Pukguksong-1 (KN-11) weapons and may be intended for pairing with the new submarine.[14]

The Philippines: In June 2020 the Philippine Navy completed what is believed to have been its longest-ever deployment when the two ships of Task Force 82 – the LPD *Davao del Sur* and the frigate *Ramon*

The Philippine Navy's amphibious transport dock *Davao Del Sur*, second of the Indonesian-built *Tarlac* class, pictured in Manila Bay in October 2019. Between January and June 2020 she participated in what has been described as the Philippine Navy's longest-ever deployment. *(US Navy)*

Alcaraz – put into Manilla Bay at the end of a five month mission. The two ships had left home waters in January to assist with the repatriation of Philippine citizens from the Middle East in the face of a deteriorating security situation marked by the US assassination of Iranian general Qasem Soleimani. Although the evacuation proved unnecessary, the ships were subsequently diverted to assist Filipino tourists stranded by the COVID-19 pandemic and collect medical supplies from India. Thereafter, an engine-room fire in *Alcaraz a*nd a cyclone in the Bay of Bengal further delayed their return. The ships finally departed Cochin in India on 27 May, travelling via Colombo in Sri Lanka to pick up more stranded citizens before concluding their epic voyage.

Also arriving in the Philippines in June was the new frigate *Jose Rizal*, the first of a pair of HDF-2600 type ships ordered from HHI and the country's first missile-armed warship. Her sister *Antonio Luna* was launched on 8 November 2019 and is due to commission before the end of 2020. The Philippine Navy has also obtained the former South Korean *Po Hang* type corvette *Conrado Yap* (the former *Chungju)* as part of the deal. HHI is also likely to be the beneficiary of a contract for two additional surface combatants that should be awarded soon. Other procurement contracts seemingly moving forward are those for two additional PT PAL-designed LPDs and six Austal enlarged 'Cape' type patrol vessels. However, previous plans to acquire a submarine capability appear to have been shelved in recognition of the fact this is likely to be beyond the country's financial capacity.

Singapore: As described further in Chapter 3.2, the Republic of Singapore Navy has completed its transition to the new *Independence* type littoral mission vessels, commissioning the final three members of the eight-ship class at a ceremony at Tuas Naval Base on 31 January 2020. The ships are intended to replace the existing patrol vessels of the *Fearless* class, which has currently been reduced to just two ships following the withdrawal of *Fearless*, *Brave* and *Dauntless* on 27 August 2019. However, the government has recently stated that it will strengthen the Multi-agency Maritime Security Task Force that protects Singapore's littoral waters by retaining and refurbishing four of the ships until purpose-built replacements can be constructed.

The most significant ongoing construction programme is that for the Type 218SG *Invincible* class submarines, the first of which was launched by ThyssenKrupp Marine Systems (TKMS) at Kiel in February 2019. She was to have been commissioned in 2021. However, recent reports suggest the COVID-19 crisis will have pushed back her delivery by around a year. Future procurement includes replacements for the *Victory* class corvettes and *Endurance* class amphibious transport docks. In January 2020 it emerged that Singapore had decided to acquire the STOVL F-35B variant of the Lightning II Joint Strike Fighter and was in the course of negotiating a contract for four aircraft – along with eight options – to evaluate the type. Although the jet's selection was largely driven by the advantages of operating a short take-off aircraft in land-scarce Singapore, the purchase holds open the prospect of the city state joining the growing number of countries deploying the aircraft at sea.

Taiwan: Always subject to a big numerical disadvantage, Taiwan's Republic of China Navy has also increasingly fallen behind the PLAN in qualitative terms over the past decade. Although the Trump administration has proved more amenable than some of its predecessors in facilitating the supply of US technology, the navy is increasingly looking to in-country solutions – particularly in the area of submarine construction – to meet its requirements. Design work on a new, indigenous boat is now believed to be close to completion, allowing manufacturing activities to commence within the next year. Recent surface warship programmes have included the commencement of series production of *Tuo Jiang* catamaran corvettes and a new class of 350-ton fast minelaying ship. Four of these are now in the course of assembly following a keel-laying ceremony for the third and fourth units on 17 April 2020. Subsequently, on 9 June 2020, a similar celebration was held for the country's first indigenous amphibious transport dock, a c. 10,500-ton vessel equipped with a well deck, large helicopter deck and associated hangar space. Being built by the country's China Shipbuilding Corporation, up to four are planned to replace obsolescent US Navy-supplied amphibious vessels.

Thailand: The Royal Thai Navy saw further progress towards achieving its long-held ambition to deploy an underwater force on 5 September 2019 when the keel of its first S26T submarine was laid at China's Wuchang Shipbuilding in Wuhan. Originally slated for delivery in 2023, it is not known to what extent this schedule will be delayed by the effects of COVID-19 on the city. Coronavirus has, however, certainly had an impact on the schedule for the planned second and third boats. Money allocated for their acquisition in the navy's 2020 budget has been diverted to Thailand's pandemic response as part of a series of reductions that will also see construction of submarine support facilities deferred.

Meanwhile, Chinese industry has benefitted from another major navy programme as the result of the 9 September 2019 signature of a contract for a Type 071E class amphibious transport dock. The purchase represents the first overseas purchase of the PLAN's 'Yuzhao' type design but it is in competition for other international contracts. Although China is taking the lion's share of recent Thai naval procurement, the country received the Korean-built DW-3000 type frigate *Bhumibol Adulyadej* in 2018 and is also building British-designed Batch II 'River' vessels under licence. The second of these – *Prachuap Khiri Khan* – was commissioned in September 2019. Her armament includes an76mm Oto Melara gun and Harpoon surface-to-surface missiles, representing a considerable upgrade on the 30mm mount installed in her British sisters.

Vietnam: Having completed a very significant programme of naval modernisation over the past few years, there has been little news of further Vietnamese naval procurement over the past twelve months. Whilst analysts differ over whether the Vietnam's People's Navy has done enough to deter Chinese maritime 'expansionism', its new submarines, frigates and fast attack craft certainly put it in a much better position than a decade ago.[15]

Notes

1. China's intentions were flagged in several official documents over the past decade. For example, the White Paper *China*'s *Military Strategy* (Beijing: Information Office of the State Council, 2015) states, 'In line with the strategic requirement of offshore waters defense and open seas protection, the PLA Navy (PLAN) will gradually shift its focus from "offshore waters defense" to the combination of "offshore waters defense" with "open seas protection" … ' Further detail of the evolution of Chinese naval strategy since the end of the Cold War can be found in Chris Rahman's 'People's Liberation Army Navy (Plan), *Navies in the 21st Century* (Barnsley: Seaforth Publishing, 2016), pp.93–104.

2. There has been some confusion over the type designations of the PLAN aircraft carriers, with *Shandong* initially being reported as a Type 001A. However, reports at the time of her commission referred to her as a Type 002 and this seems to be the official position. Among the first to note the correct designations was Rick Joe, in 'A Mid-2019 Guide to Chinese Aircraft Carriers' posted to *The Diplomat* website – thediplomat.com – on 18 June 2019. China was just beaten by the British Royal Navy in inducting a second aircraft carrier, with *Prince of Wales* commissioning seven days previously.

3. See *Defence 2000: Our Future Defence Force* (Canberra: Commonwealth of Australia, 2000), pp.84 & 90.

4. The Australian National Audit Office report, *Auditor-General Report No.22 2019–20: Future Submarine Program –Transition to Design* (Canberra: ANAO, 2020) is available by searching www.anao.gov.au. Previous estimates of the *Attack* programme's cost were reported to be AU$50bn but evidence presented to Australia's Commonwealth, Senate Foreign Affairs, Defence and Trade Legislation Committee on 29 November 2019 referenced the higher figure. Both amounts are heavily impacted by the likely effects of inflation over a very long production timescale. This also partly explains the huge estimate of sustaining the submarines out to planned retirement in around 2080, which is estimated to be a further AU$145bn.

5. See Michael Evans, 'US would lose any war fought in the Pacific with China', *The Times* – 16 May 2020 (London: Times Newspapers Ltd, 2020).

6. The document 'UPDATED China: Naval Construction Trends vis-à-vis U.S. Navy Shipbuilding Plans, 2020-2030' was prepared for the US Senate Armed Services Committee on 6 February 2020 and later released to the Federation of American Scientists in redacted form as a result of a Freedom of Information Request. It can be found by searching www.fas.org. The report is also analysed in Ronald O'Rourke's *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress RL33153* (Washington, D.C.: Congressional Research Service, 2020).

7. See Minnie Chan, 'China's engineers in race to build best stealth jet for nation's aircraft carriers' posted to the *South China Morning Post*'s website – scmp.com – on 19 July 2019. Subsequent articles suggest the Chengdu J-20 – already in service with the People's Liberation Army Air Force – is the favourite to be selected for further development.

8. For further analysis of the construction work and the potential construction programme see H I Sutton's article, 'Chinese Navy Steps Closer To New Generation Of Nuclear Submarines' posted to the *Forbes* site – www.forbes.com – on 19 June 2020.

9. Both stories were carried by *Jane*'s *Defence Weekly*. See Andrew Tate's 'Images reveal dimensions of China's 'sailless' submarine' and Kelvin Wong's 'CSIC expands unmanned surface warfare portfolio with JARI', respectively carried in the 16 October and 23 September 2019 editions (Both Coulsdon: IHS Jane's, 2019).

10. See *National Defense Program Guidelines for FY2019 and beyond* and *Medium Term Defense Program (FY 2019 - FY 2023)* (both Tokyo: Government of Japan, 2018).

11. See *Defense Programs and Budget of Japan: Overview of JFY2020 Budget* (Tokyo: Ministry of Defence, 2019) which can be found by searching the ministry's website at: https://www.mod.go.jp/e/

12. Indonesia's stance caused some surprise, as its territorial claims reportedly do not directly conflict with China's beyond some EEZ overlap with the nine dash line. See Koya Jibiki, 'Indonesia says China's "nine-dash line" puts its interests at risk' posted to *The Financial Times* website – www.ft.com – on 15 June 2020.

13. See *Defence White Paper: A Secure, Sovereign & Prosperous Malaysia* (Kuala Lumpa: Ministry of Defence, 2020). This can be found by searching the ministry's website at: www.mod.gov.my/ms

14. Two sites provide useful, regular updates on North Korea's strategic submarine programme. These are The Henry L. Stimson Center think tank's *38 North* project at www.38north.org and defence analyst H I Sutton's *Covert Shores* site at www.hisutton.com.

15. For a detailed overview of Vietnam's naval modernisation, as well as the strategy and limitations behind it, see Felix K Chang, 'Resist and Reward: Vietnam's Expansion' posted to the Philadelphia-based Foreign Policy Research Institute's site – www.fpri.org – on 6 November 2019.

2.3 REGIONAL REVIEW

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THE INDIAN OCEAN AND AFRICA

The last twelve months have seen instability and conflict continue to permeate the vast, diverse Indian Ocean, African and Middle Eastern region. Whether they relate to clashes between Chinese and Indian soldiers high in the Himalayas or piracy in the Gulf of Guinea, the region has been making headlines for all the wrong reasons.

The greatest tensions continue to exist in the Middle East. The largely proxy war between Iran on the one hand and Saudi Arabia and its allies on the other has progressed largely unabated in spite of the deadly addition of COVID-19 into the mix of regional woes. The epicentre of combat remains Yemen, where the Saudi Arabian-led coalition is seemingly on the back foot five years after its intervention against the rebel Houthi movement in the country's civil war. A 'war within a war' between the Saudi Arabian backed-government and the Southern Transitional Council (STC) that is supported by key coalition partner the United Arab Emirates has been a major complicating factor. The intervention has undoubtedly stretched Saudi military resources at a time when lower oil prices are squeezing its defence spending. Its resulting vulnerability was underlined on 14 September 2019 when drone and cruise missile strikes widely believed to have been launched by Iran caused significant, if short-term, damage to the giant Abqaiq and Khurais oil processing facilities that account for around half Saudi Arabia's total output.[1]

From a maritime perspective, the focal point for potential conflict remains the key trade artery of the Persian Gulf. A series of limpet mine attacks on tankers that occurred during May and June 2019 was followed by the seizure of the British-flagged tanker *Stena Impero* on 20 July in retaliation for the arrest off Gibraltar of an Iranian tanker suspected of violating EU sanctions against Syria. Although both vessels and their crews were later released, the ongoing threat to shipping has resulted in the creation of a US-sponsored International Maritime Security Construct to secure freedom of navigation in the area. International support for the initiative has been mixed. This partly reflects unease over the Trump administration's hawkish stance on Iran's nuclear programme and a desire to avoid being dragged into a wider conflict.

The very real risks of this eventuality were demonstrated by the United States' assassination of leading Iranian Islamic Revolutionary Guard Corps General Qasem Soleimani by a drone strike at Baghdad International Airport on 3 January 2020, allegedly in retaliation for Iranian-organised attacks on US facilities in Iraq.[2] Although Iran's response has been unexpectedly restrained, the possibility of further escalation as a result of a miscalculation remains. President Trump's 22 April 2020 tweet that he had '… instructed United States Navy to shoot down and destroy any and all Iranian gunboats if they harass our ships at sea' can hardly be seen as helpful in these circumstances.

Meanwhile, another potential front for conflict has been opened as a result of a steady deterioration in relations between Turkey and Egypt. This has its origins in Turkish President Erdoğan's past support for the Egyptian Morsi regime ousted in the coup of 2013. However, it is now being driven by Turkey's active involvement in Libya's civil war and a perception that is seeking wider regional hegemony.[3] In June 2020, Egyptian President Sisi warned that Egypt could intervene militarily in Libya if the Turkish-backed – and United Nations-recognised – Government of National Accord (GNA) continued its eastward-advance against rebel forces.

A key factor underlying the friction between Turkey and Egypt is a race to carve up underwater resources in the Eastern Mediterranean. In November 2019, the GNA and Turkey signed an accord over maritime rights that potentially pit them against the interests of a number of other countries – notably Cyprus, Greece, Egypt and Israel – in exploiting regional oil and gas reserves. This backdrop is another potential explanation for the remarkable recent investment in Egyptian naval power, often reported as being a Saudi Arabian-financed initiative to help counter Iranian influence. The spring of 2020 saw reports emerge of further expansion in the form of a massive armaments deal with Italy. Two FREMM frigates under construction for the Italian Navy are said to be part of the transaction, along with as many as four additional frigates and twenty corvettes. If confirmed, the new ships will join French amphibious assault ships and surface combatants, as well as German submarines and frigates, that have either already been delivered or are in the course of construction.

The Egyptian Navy's 'Gowind 2500' type corvette *Port Said* pictured under construction at Alexandria Shipyard shortly before launch in September 2018. She is reportedly the first modern major surface combatant completed in the African continent. Instability in the Middle East and maritime tensions in the Mediterranean are spurring a significant, if somewhat eclectic, Egyptian naval procurement programme. *(Cyril Abad/Naval Group)*

Table 2.3.1: FLEET STRENGTHS IN THE INDIAN OCEAN, AFRICA AND THE MIDDLE EAST – LARGER NAVIES (MID 2020)

COUNTRY	ALGERIA	EGYPT	INDIA	IRAN	ISRAEL	PAKISTAN	SAUDI ARABIA	SOUTH AFRICA
Aircraft Carrier (CV)	–	–	1	–	–	–	–	–
Strategic Missile Submarine (SSBN)	-	-	1	-	-	-	-	-
Attack Submarine (SSN/SSGN)	–	–	1	–	–	–	–	–
Patrol Submarine (SSK/SS)	6	7	14	4	5	5	–	3
Fleet Escort (DDG/FFG)	2	8	23	–	–	8	7	4
Patrol Escort/Corvette (FFG/FSG/FS)	10	4	12	7	3	1	4	–
Missile Armed Attack Craft (PGG/PTG)	c.12	c.30	8	c.25	8	9	9	3
Mine Countermeasures Vessel (MCMV)	1	c.14	–	–	–	3	3	4
Major Amphibious (LPD)	1	2	1	–	–	–	–	–

Notes:

1 Algerian fast attack craft and Egyptian fast attack craft and mine-countermeasures numbers approximate.

2 Iranian fleet numbers exclude large numbers of indigenously-built midget and coastal submarines, as well as numerous missile-armed craft operated by the Revolutionary Guard.

3 The South African attack craft and mine-countermeasures vessels serve in patrol vessel roles.

INDIA

Although the Indian defence budget has grown to become one of the three largest in the world, the picture on the ground is not so rosy. Salary and pension costs continue to swallow a large proportion of total Indian Ministry of Defence spending, expanding from around 50 percent to 60 percent of the total in the last decade. This has resulted in inadequate funding for the more capital-intensive air force and navy, the latter accounting for a mere 15 percent of the defence budget. The navy has struggled to pay for existing commitments, let alone launch new programmes.[4]

India's 2020–1 defence budget goes some way to addressing this situation. The c. INR256bn (US$3.4bn) allocated to naval modernisation represents a 16 percent increase on last year's comparable figure. However, the extent of the shortfall against the navy's arguably inflated ambitions has meant that something has had to give. In late 2019 it emerged that the previous target of achieving a 200-ship fleet under a classified medium term Maritime Capability Perspective Plan has been reduced to just 175 vessels. Moreover, India's chief of naval staff has acknowledged that this objective is still 'optimistic'. Cuts to acquisitions are believed to include cancellation of four planned amphibious assault ships; a reduction in the mine countermeasures vessel replacement programme from twelve to eight units; and pruning of a number of naval aviation projects.[5] There has also been speculation that procurement of the high profile second indigenous aircraft carrier (IAC-2) will be pushed further to the right, if not cancelled altogether.

Some important purchases are still proceeding. In February 2020 a long-awaited c. US$2bn contract was awarded for the construction of five 45,000-ton fleet support ships. They will be built by state-owned Hindustan Shipyards Ltd (HSL) with the assistance of the Turkish TAIS consortium. Signature of the deal had been delayed by several months due to political and security concerns over Turkish involvement, particularly given the Turkish shipbuilding sector's active involvement in Pakistan's naval programmes. Subsequently, in May 2020, it was announced that another long-delayed acquisition had been finalised with the procurement of twenty-four MH-60R sea control helicopters from Lockheed-Martin. The rotorcraft will be delivered between 2021 and 2024, providing a major boost to the navy's somewhat depleted anti-submarine warfare capabilities.

Current Indian Navy composition is provided in Table 2.3.2, with developments relating to major types summarised below:

Aircraft Carriers: Physical construction of India's first indigenous aircraft carrier (IAC-1) *Vikrant* is now complete, with main propulsion system and power generation trials conducted in the second half of 2019. However, the impact of the COVID-19 crisis has reportedly pushed back the start of basin trials that were due to commence in March 2020. This seems likely, in turn, to delay sea trials until the end of 2020 at the earliest. Meanwhile, trials of the naval variant of the indigenous Light Combat Aircraft (LCA) commenced from the existing carrier *Vikramaditya* (the former *Admiral Gorshkov*) in January 2020. The navy has already determined that the existing design is insufficiently powerful for operational use but is looking to acquire a twin-engine Mk 2 aircraft that is expected to commence flying in the second half of the decade.

Major Surface Combatants: The number of Indian

Table 2.3.2: INDIAN NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier (CV)	Project 1143.4 **VIKRAMADITYA** (KIEV)	1	45,000 tons	283m x 31/60m x 10m	Steam, 30 knots	1,600	1987
Principal Surface Escorts							
Destroyer – DDG	Project 15A **KOLKATA**	3	7,400 tons	163m x 17m x 7m	COGAG, 30+knots	330	2014
Destroyer – DDG	Project 15 **DELHI**	3	6,700 tons	163m x 17m x 7m	COGAG, 32 knots	350	1997
Destroyer – DDG	Project 61 ME **RAJPUT** ('Kashin')	4	5,000 tons	147m x 16m x 5m	COGAG, 35 knots	320	1980
Frigate – FFG	Project 17 **SHIVALIK**	3	6,200 tons	143m x 17m x 5m	CODOG, 30 knots	265	2010
Frigate – FFG	Project 11356 **TALWAR**	6	4,000 tons	125m x 15m x 5m	COGAG, 30 knots	180	2003
Frigate – FFG	Project 16A **BRAHMAPUTRA**	3	4,000 tons	127m x 15m x 5m	Steam, 30 knots	350	2000
Frigate – FFG	Project 16 **GODAVARI**	1	3,850 tons	127m x 15m x 5m	Steam, 30 knots	315	1983
Corvette – FSG	Project 28 **KAMORTA**	4	3,400 tons	109m x 13m x 4m	Diesel, 25 knots	195	2014
Corvette – FSG	Project 25A **KORA**	4	1,400 tons	91m x 11m x 5m	Diesel, 25 knots	125	1998
Corvette – FSG	Project 25 **KHUKRI**	4	1,400 tons	91m x 11m x 5m	Diesel, 25 knots	110	1989
Submarines							
Submarine – SSBN	**ARIHANT**	1	7,500+ tons	112m x 11m x 10m	Nuclear, 25+ knots	100	2016
Submarine – SSN	Project 971 **CHAKRA** ('Akula II')	1	9,500+ tons	110m x 14m x 10m	Nuclear, 30+ knots	100	2012
Submarine – SSK	Project 75 **KALVARI** ('Scorpène)	2	1,800 tons	68m x 6m x 6m	Diesel-electric, 20 knots	45	2017
Submarine – SSK	Project 877 EKM **SINDHUGHOSH** ('Kilo')	8	3,000 tons	73m x 10m x 7m	Diesel-electric, 17 knots	55	1986
Submarine – SSK	**SHISHUMAR** (Type 209)	4	1,900 tons	64m x 7m x 6m	Diesel-electric, 22 knots	40	1986
Major Amphibious Units							
Landing Platform Dock – LPD	**JALASHWA** (AUSTIN)	1	17,000 tons	173m x 26/30m x 7m	Steam, 21 knots	405	1971

major surface combatants has increased by one year-on-year with the delivery of the fourth and final Project 28 *Kamorta* class corvette, *Kavaratti*, on 18 February 2020. With the unmodernised Project 61 ME destroyer *Rana* and the final *Godavari* class frigate, *Gomati*, likely to be decommissioned soon it seems that this will be the high-water mark of surface fleet strength for the immediate future.

Future fleet additions continue to be dominated by three major programmes. Four Project 15B *Visakhapatnam* class destroyers remain in various stages of construction at Mumbai's renamed Mazagon Dock Shipbuilders Ltd (MDSL). The current, already delayed delivery schedule suggests the ships will enter service at annual intervals from 2021 onwards. However, the fact that approval for their weapons and sensor package has only recently been forthcoming indicates that this is unlikely to be achieved. Revisions to the weapons package – that includes an extended-range variant of the Indo-Russian BrahMos surface-to-surface missile and Israeli surface-to-air missiles and radar systems – have taken total programme cost to INR358bn (c. US4.7bn).

MDSL is working in collaboration with Kolkata's Garden Reach Shipbuilders & Engineers (GRSE) to deliver seven Project 15A frigates on the basis of a four/three split. The yard launched the first of the class – named *Nilgiri* – on 28 September 2019. It laid the keel for a second vessel in May 2019, whilst GRSE has also commenced work on two of the ships. Previous reports have suggested the use of modular construction techniques will reduce post-launch outfitting and, therefore, total construction times. However, pictures of *Nilgiri* at launch do not suggest marked improvement in this regard. This suggests a schedule that sees deliveries targeted to commence in late 2022 is also overly-optimistic.

Delays are also impacting the third major project, which involves the delivery of four modified, Russian-designed Project 11356 *Talwar* class frigates to add to the six already in commission. Two of these will be supplied by the Yantar shipyard in Kaliningrad. It will complete ships previously ordered for the Russian Navy but suspended after Ukraine refused to supply their gas turbines. Initial announcements suggested these could be delivered during 2022–3 but this has now slipped to 2024 according to recent press reports. An additional pair – which are scheduled to be completed by Goa Shipyard Ltd with Russian technical assis-

The likely cancellation of the Indian Navy's project to acquire new amphibious assault ships means that smaller tank landing ships such as *Arivat* – pictured here on exercises with the US Navy in November 2019 – will provide the navy's main amphibious capability for the foreseeable future. *(US Navy)*

The Indian Navy is now seeing its considerably delayed Project 75 submarine programme starting to deliver a considerable uplift in capabilities to its underwater flotilla. This is second of class *Khanderi* on 27 September 2019; the day before she was formally commissioned. *(Indian Navy)*

tance – are unlikely to be delivered much before the end of the decade.

Submarines: There is better news with respect to India's underwater forces. The second MDSL-built Project 75 'Scorpène' type submarine *Khanderi* was commissioned on 28 September 2019 after previously reported construction defects were apparently satisfactorily resolved. A third boat, *Karanj*, is undergoing sea trials and the three other members of the class are at various stages of construction. Recent articles in the Indian press suggest that all the boats may be fitted with an indigenous fuel cell-based AIP module when they enter their first refit cycle.

The arrival of *Khanderi* counterbalances the loss of the Project 877EKM 'Kilo' class submarine *Sindhivir*, which is due to be transferred to Myanmar following recent completion of a refit at HSL. Russia has reportedly proposed a 'three plus three' deal to India that would involve modernisation of three other Project 877EKM class boats at the Zvezdochka shipyard along with the supply of three refurbished Russian Navy 'Kilos'. This would essentially be a stopgap solution to bolster the existing force structure until the long-delayed Project 75(I) programme can be brought to fruition.[6]

News flow on India's secretive strategic submarine programme continues to be limited. Reports indicate that sea trials of the second ballistic missile-armed submarine, *Arighat*, are well underway but suggestions she will be commissioned before the end of 2020 seem to be speculative. The first two strategic submarines will be equipped, at least initially, with the short-ranged K-15 'Sagarika' ballistic missile but a longer-ranged K-4 intermediate-range weapon is under development and will likely equip follow-on boats as they enter service. Two successful tests of the missile were concluded in January 2020, paving the way for it to enter serial production.

OTHER INDIAN OCEAN NAVIES

Bangladesh: The Bangladesh Navy continues to follow a twin-track expansion policy that is largely based on the purchase of major units from China being supplemented by local construction of smaller ships. December 2019 saw another major milestone in this approach with the transfer of two former People's Liberation Army Navy (PLAN) Type 053H3 'Jiangwei II' class frigates into Bangladesh's service following refurbishment at Shanghai. The former *Jiaxing* and *Lianyungang*, which have become *Abu Ubaidah* and *Umar Farooq*, were first commissioned at the end of the 1990s. They are essentially a generation further forward than the three Type 053H1 and H2 'Jianghus' previously transferred. Their acquisition provides Bangladesh with a total of eight frigate-sized vessels, with the sole 'Ulsan' class frigate *Bangabandhu* and two former US Coast Guard *Hamilton* (WHEC-715) class high endurance cutters making up the numerical balance. There are also six smaller corvette-sized vessels – four newly-built C-13B derivatives of the Chinese Type 056 design and two upgraded former 'Castle' class offshore patrol vessels transferred from the British Royal Navy. The third of the C-13Bs – *Sangram* – was formally commissioned by Bangladesh's Prime Minister Sheikh Hasina on 18 June 2020; over a year after her first arrival in home waters. Unusually, the ceremony was performed by video link in view of the COVID-19 crisis.

Meanwhile local construction is largely focused in the government-owned Khulna Shipyard, which has been under direct navy management since 1999. Its current naval contracts are focused on the c. 350-ton *Padma* class patrol vessel design. An initial batch of five of these ships was delivered with Chinese technical support in 2013 and a further three were handed over to the coast guard in 2019. These are now being followed by a further batch of five ships, which will be operated by the navy as coastal patrol vessels. The Khulna yard has also previously been involved in construction of somewhat larger *Durjoy* class anti-submarine patrol vessels. However, plans for additional units may have to await completion of the latest *Padma* class order.

Myanmar: The rapidly growing profile of the Myanmar Navy has been boosted by its delivery of two major surprises over the past year. In July 2019 it emerged that India was set to help the navy realise its ambition to develop an underwater arm with the transfer of the 'Kilo' class submarine *Sindhivir* alongside an appropriate package of training and support. The agreement allows Myanmar to counter Bangladesh's acquisition of two former Chinese Type 053G 'Ming' class submarines – both commissioned in 2017 – whilst helping India reduce China's influence in its backyard. The new submarine was initially due to arrive in Myanmar in early 2020. However, the transfer seems to have been delayed by COVID-19 related concerns.

In the interim, December 2019 saw Myanmar commission its first LPD type amphibious transport dock. Built by South Korea's Dae Sun Shipbuilding & Engineering, the 11,500-ton *Mottama* is similar to a series of vessels previously acquired by Indonesia, the Philippines and Peru. Although only lightly armed, she has a flight deck that can accommodate two medium helicopters, a well deck for two utility landing craft and space to transport a consid-

The Myanmar Navy delivered two major surprises over the past year – an announcement that a submarine was to be acquired from India and the commissioning of its first amphibious transport dock. The commissioning of the latter vessel – the 11,500-ton *Mottama* – took place alongside a number of other newly-acquired vessels on 24 December 2019. *(Myanmar Navy)*

erable embarked force and their equipment. She is yet a further sign of Myanmar's intention to become a significant power in the Bay of Bengal.

Pakistan: The Pakistan Navy's long-delayed modernisation plans are now starting to gain traction, holding out the prospect of halting a decade or more of decline in comparison with local rival India. The most advanced programme relates to construction of two 2,300-ton Damen 'OPV1900' corvettes. Ordered in 2017, these are both being completed by the group's Galati yard in Romania after plans to complete one at Pakistan's Karachi Shipyards & Engineering Works (KSEW) were revised. Essentially built to commercial design standards, they will be fitted with a range of weapons after delivery. The lead vessel, named *Yarmook*, was handed over in February 2020. Delivery of her sister, launched in September 2019, is said to be imminent. Press reports suggest there is also a requirement for two additional units of the type.

Whilst the two Damen vessels represent a relatively modest capability, more potent units are on the way. Construction is now underway on all four Type 054A(P) frigates ordered from China in two batches during 2017 and 2018 and it seems likely deliveries will commence before the end of 2021. They are likely to replace Pakistan's remaining former British Royal Navy Type 21 frigates, only three of which are now believed to remain in service following disposal of *Tippu Sultan* (the former *Avenger*) in a missile firing exercise in April 2020. A little further down the line are a quartet of modified Turkish 'Milgem' light frigates, which will be known as the *Jinnah* class in Pakistan Navy service. In contrast to the Damen and Chinese supplied ships, construction of these vessels will be split between Istanbul Naval Shipyard and KSEW. A steel-cutting ceremony for the first ship was held in September 2019, with keel laying following on 4 June 2020. Delivery is expected towards the end of 2023, with subsequent ships following at six-monthly intervals. Meanwhile, KSEW are close to completing the fourth, redesigned member of its *Azmat* fast attack craft following a launch ceremony on 27 November 2019.

By 2023 Pakistan should also be taking delivery of the first of its new AIP-equipped *Hangor* class submarines, an export derivative of the Chinese Type 039A 'Yuan' design. Eight of these are scheduled for completion in two batches by 2028, the later quartet also to be completed by KSEW.[7]

Yarmook is the first of two Damen 'OPV1900' series offshore patrol vessels being acquired to undertake corvette-type roles by the Pakistan Navy. Construction of both ships has been undertaken by Damen's Galati facility in Romania but outfitting of military equipment will take place in Pakistan. *(Damen)*

Sri Lanka: The Sri Lankan Navy is another Indian Ocean fleet benefitting from the availability of second-hand PLAN equipment in a sign of ongoing Chinese influence that is of clear concern to neighbouring India. The refurbished Type 053H2G 'Jiangwei I' class frigate *Parakramabahu* (formerly *Tongling*) – effectively a half-sister of the 'Jiangwei II' type vessels recently acquired by Bangladesh – arrived in Colombo on 8 July 2019 following her transfer the previous month in Shanghai. The navy has also taken delivery of new-build Indian offshore patrol vessels and a former US Coast Guard cutter in recent years, reflecting the ongoing attention the major naval powers are paying to the strategically-located island.

AFRICAN NAVIES

Sub-Saharan Africa's leading fleet – **South Africa's** navy – put on a display of naval power in September 2019. Two frigates and a submarine bracketed an assortment of other vessels in a fleet review – the first since 2008 – held to celebrate the 25th anniversary of democratic elections. However, the financial backdrop is anything but positive given continued real-terms reductions in defence spending and the diversion of resources to fund the COVID-19 response. One sign of the strain is the amount of time the fleet has been able to spend at sea – an average of around 7,300 hours in the three years to FY2018/19 compared with a target of 12,000 hours. Although progress with Projects Biro (for three inshore patrol vessels) and Hotel (for a new hydrographic survey ship) is reportedly on track, there are concerns whether the two programmes will run into funding constraints given the stretched funding environment.[8]

The funding backdrop is far more positive in West Africa. Here a combination of maritime insecurity in the Gulf of Guinea (GoG) and an increasing focus on EEZ protection of funding something of a procurement spree. The GoG remains a hotspot for maritime crime, with the number of crew kidnapped in the region increasing by more than half from 78 in 2018 to 121 in 2019. This equated to over 90 percent of global kidnappings reported at sea.[9] Many

Senegal has been acquiring a range of naval vessels to bolster its maritime security capacity. This picture shows one of the Israel Shipyards' Shaldag Mk 2 fast interceptors that will be deployed in the country's coastal waters. *(Israel Shipyards)*

countries are following the lead of **Nigeria** – responsible for the region's leading navy and subject to a separate report in Chapter 2.3A – in bolstering constabulary assets and supporting infrastructure. For example, **Ghana** has announced plans to construct a string of new forward operating bases starting with a facility at Ezinlibo near the country's western oilfields. Purchases of new offshore and coastal patrol boats also form part of the plan. Further to the north, **Senegal** is in the course of taking delivery of Shaldag Mk 2 fast patrol boats from Israel Shipyards. It also signed a contract for three missile-armed, 62m OPV 58S offshore patrol vessels from France's Piriou in November 2019. Images of the latter design suggest the ships will incorporate a 360° panoramic bridge, a stern ramp for two inflatable boats and a 76mm main gun. Other recent acquisitions include RPB 33 patrol boats from France's Radico Marine and the larger French-built patrol vessels *Kedougou* and *Fouladou.*

A graphic of the Israel Shipyards S72-based concept that has been chosen for development under the Reshef programme to replace the Israeli Navy's existing SA'AR 4.5 missile-armed fast attack craft. *(Israel Shipyards)*

Turning to North Africa, **Egypt** is undoubtedly the focal point of procurement activity.[10] Although the proposed armaments contract with Italy referenced in the introduction has yet to be confirmed, previously agreed transactions are resulting in a steady stream of new equipment reaching the Egyptian Navy. The most prominent arrival in the past year has been the Type 209 submarine *S43.* She berthed in Alexandria on 5 May 2020 after being handed over by ThyssenKrupp Marine Systems (TKMS) in Germany the previous month. The third of a quartet of boats ordered in two batches in 2011 and 2015, she should be followed by her sister *S44* within the next year.

By then Egypt should also have seen the completion of *Port Said*, its second Naval Group 'Gowind 2500' type corvette and the first to be assembled 'in country' by Alexandria Shipyard. Two further members of the class are under construction in Alexandria, with the fourth and final ship – named *Luxor* – launched in May 2020. Egypt held discussions with France to purchase another two Gowind vessels. However, it ultimately decided to acquire MEKO A200 frigates from TKMS, possibly as a result of the cooling of the previous Franco-Egyptian relationship due to Egypt's poor human rights record.[11] Although previous reports suggest a six-ship programme, it seems that the initial order is for just four frigates. Egypt also continues to make significant investment in infrastructure to support its new equipment. In January 2020, President Sisi opened a massive new 150,000-acre base complex at Berenice on the Red Sea. Equipped with 1,000m of berthing facilities and an airfield with two 3,000m runways, the facility is clear evidence of Egypt's intention to play a major maritime security role in the southern approaches to the Suez Canal.

Although Egypt has overtaken **Algeria** as the main destination of warship deliveries to North Africa, it remains the other major naval power of note on the Mediterranean's southern shore. Having commissioned a number of new submarines and major surface combatants in recent years, its current focus is on inducting a second batch of French OCEA FPB 98 coastal patrol vessels. Ten of these are currently in the course of delivery, following on from an initial batch of twenty-one acquired between

2008 and 2012. Other ongoing construction programmes encompass Italian minehunters and Chinese offshore patrol vessels, although there has been little news of consequence with respect to either project over the past year.

MIDDLE EASTERN NAVIES

Israel is another Mediterranean country that is responding to increased maritime tension with a significant programme of investment. 2020 should see the delivery of the submarine *Drakon* – the third of a second batch of three 'Dolphin II' class submarines and sixth member of the class overall – from TKMS in Kiel. Also close to delivery from Kiel is *Magen*, the first of four SA'AR 6 corvettes ordered in 2015. With a length of 90m and a displacement close to 2,000 tons, she is larger than existing Israeli Navy vessels and better suited to protecting the country's EEZ interests. She commenced trials early in March 2020 and is expected to arrive in Israel by the end of the year for further outfitting of Israeli-manufactured equipment in a new floating dock ordered from Israel Shipyards. Israel Shipyards has also been awarded a contract to develop its S-72 concept as the basis for a new 'Reshef' class of fast attack craft. These vessels will eventually replace the eight SA'AR 4.5 vessels that are now approaching retirement.

Construction of *Saud*, the first of four Lockheed Martin multi-mission surface combatants derived from the *Freedom* (LCS-1) Littoral Combat Ship design is now underway at Fincantieri's Marinette Marine yard in Wisconsin. *(Lockheed Martin)*

Turning to the Arab world, **Saudi Arabia** has achieved progress with its own programme of fleet renewal – sometimes referred to as the Saudi Naval Expansion Programme II – over the past year. On 24 October 2019, Fincantieri's Marinette Marine yard in Wisconsin held a ceremony to mark the start of construction work on *Saud*, the first of four multi-mission surface combatants ordered by the Royal Saudi Navy. Derived from the Lockheed Martin *Freedom* (LCS-1) design, the ships benefit from improvements such as incorporation of a vertical launch system. They will probably form the lead units of the country's Eastern, Persian Gulf-based Fleet. Work is also continuing on the five-ship 'Avante 2200' corvettes that will operate with the *Saud* class under a contract with Spain's Navantia. The keel of the lead ship, *Al-Jubail*, was laid at the company's San Fernando yard near Cadiz on 1 October 2019 following a first steel cutting ceremony in January of that year. She is due to be launched in July 2020. Other new construction includes three Combattante FS56 fast attack craft being built by France's CMN under a contract taken over from the Lebanese Armed Forces and as many as thirty-nine of the company's HIS-32 interceptors. The first twenty-one of these are being delivered from the company's Cherbourg facility with the remainder due be assembled at Zamil Offshore Services' yard in Saudi Arabia.

Two Navantia 'Avante 2200' corvettes pictured under construction in mid-2020. The nearer, *Al-Jubail*, is scheduled for launch in July 2020. *(Navantia)*

Ongoing tensions in the Gulf continue to be a spur for naval procurement across the region. This ranges from new 'Gowind' type corvettes for the **United Arab Emirates** to the potential sale of a second former US Navy FFG-7 class frigate – the former *Robert G. Bradley* (FFG-49) – to **Bahrain.** However, the most ambitious programme of naval expansion currently underway is being undertaken by **Qatar**. Alongside the perceived threat from Iran, the small emirate also faces the challenge of ongoing sanctions from many fellow members of the Gulf Cooperation Council over its support for radical Islamic organisations. Already in the middle of a major acquisition of warships from Italy's Fincantieri, it has signed a new memorandum of understanding with the company covering potential future acquisitions that could extend to submarines. Meanwhile, tangible progress with the existing programme was demonstrated by the launch of *Al Zubarah*, the first of four 3,000-ton 'corvettes', at Fincantieri's Muggiano yard on 27 February 2020. The c. 107m long vessel will be capable of speeds of up to 28 knots from a CODAD power plant. A powerful multi-mission armament includes Aster 30 area-defence missiles, whilst provision is made for a hangar and flight deck large enough to house a medium-sized helicopter.[12]

Any assessment of **Iran's** naval forces – comprising both the Islamic Republic of Iran Navy and the independent Iranian Revolutionary Guard Corps Naval Forces – is fraught with hazard given significant levels of official disinformation about true capacity. In broad terms, the focus remains on asymmetric A2/AD capabilities based on large numbers of small fast attack craft and midget submarines, supplemented by coastal missile batteries. However, there remains an interest in deploying somewhat larger submarines and surface vessels. This is probably both to allow long-range deployments and for reasons of prestige. Construction of large surface vessels has tended to be based on 'cloned' derivatives of existing imported types. The most noteworthy of these are 'Sina' class missile-armed fast attack craft based on the 'Combattante II' design and the 'Mowj' series of frigates based on the Vosper Thornycroft *Alvand* type. Two of the 'Mowj' class are believed to be in service in the Persian Gulf following the delivery of *Sahand* to join her sister *Jamaran* at the end of 2018. However, *Damavand* – which sank after a grounding accident at Bandar Anzali on the Caspian Sea in January 2018 – is believed to be beyond repair. A replacement, modernised version equipped with a VLS system is reportedly under construction.[13] Additionally, at least one further 'Mowj' class frigate – named *Derna* – is close to joining the Persian Gulf fleet.

Notes

1. One of the problems that Saudi Arabia faces is that many of the Patriot surface-to-air missile batteries that form the heart of its air-defence network have been shifted southwards to counter the threat from Houthi ballistic missiles. This has left defences against Iran in the north-east thinly spread.

2. The targeted killing of General Soleimani – a senior officer of a sovereign nation – has been controversial. The *New York Times* suggested that the last time the United States killed a major foreign military leader was when the plane carrying the Japanese admiral Isoroku Yamamoto was shot down during the Second World War in April 1943. See, Helene Cooper, Eric Schmitt, Maggie Haberman and Rukmini Callimachi, 'As Tensions With Iran Escalated, Trump Opted for Most Extreme Measure', *The New York Times* – 4 January 2020 (New York: The New York Times Ltd, 2020).

3. A good overview of the background to the tensions between Egypt and Turkey was provided in an article by Khalil al-Anani, 'Egypt-Turkey Strained Relations: Implications for Regional Security' posted to the Arab Center Washington DC's website – www.arabcenterdc.org – on 18 March 2020.

4. This is inevitably a brief summary of a highly complex subject. Laxman K Behara's series of annual reviews of Indian defence spending posted to India's Ministry of Defence funded but autonomous Institute for Defence Studies and Analyses (IDSA) continue to provide indispensable analysis of the structure and trajectory of the military's budget. These can be found by searching the IDSA website at www.idsa.in.

5. See Manu Pubby, 'Indian Navy cutting down on procurement due to Budget cuts' posted to *The Economic Times* website – www.economictimes.com – on 16 January 2020.

6. See Rahul Bedi, 'Russia offers India new submarine deal' in *Jane's Defence Weekly* – 15 April 2020 (Coulsdon: Janes Group UK, 2020), p.5. India currently operates five 'Kilos' that have been refitted by Zvezdochka – a sixth, *Sindhurakshak*, was destroyed in an explosion in 2013 – and the Russian proposal would encompass the remaining boats in Indian service. The three additional submarines might be seen as replacements for the three members of the four-strong German-designed Type 209 *Shishumar* class that have not yet embarked on modernisation.

7. The Quwa website – www.quwa.org – remains an excellent source of news and analysis on Pakistan Navy programmes.

8. The defenceWeb news portal – www.defenceweb.co.za – provides a unique source of ongoing coverage of security and defence procurement news across the African continent. It contains much supplemental information to the summary in this chapter.

9. Further details of regional and global piracy are provided in the news section of the ICC's Commercial Crime Services website, accessible at: icc-ccs.org

10. According to the Stockholm International Peace Research Institute (SIPRI), Egyptian arms imports more than doubled between the five-year periods 2010–14 and 2015—19. This made Egypt the world's third largest armaments importer after Saudi Arabia and India during this timescale. See Pieter D Wezeman, Aude Fleurant, Alexandra Kuimova, Diego Lopes Da Silva, Nan Tian & Siemon T Wezeman, *SIPRI Fact Sheet: Trends in International Arms Transfers 2019* (Stockholm: SIPRI, 2020).

11. Interesting background to the thought process behind Egypt's somewhat eclectic naval acquisitions is provided by Derek Bisaccio in an article, 'Gunboats and Diplomacy' posted to defence consultancy Forecast International's *Defense & Security Monitor* blogsite at – www.dsm.forecastinternational.com/wordpress – on 5 March 2020. He argues Egypt's priority is to cultivate ties with a number of suppliers rather than rely on any one in particular, allowing it to circumvent external pressure on its policies. This is regarded as outweighing cost and compatibility issues arising from maintaining a diverse range of equipment.

12. A detailed review of current Gulf procurement programmes was provided by Tim Fish in 'Briefing: Naval modernisation in the Gulf – Rising tide' published in *Jane's Defence Weekly* – 12 February 2020 (Coulsdon: IHS Jane's, 2020), pp.22–8.

13. See Jeremy Binnie, 'Iran building replacement Caspian frigate with VLS', *Jane's Defence Weekly* –14 August 2019 (Coulsdon: IHS Jane's, 2019), p.19.

2.3A FLEET REVIEW

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THE NIGERIAN NAVY

Making slow headway against heavy seas

With both the largest population and the largest economy in Africa, Nigeria is one of the continent's powerhouses. Given the overall importance of oil production – accounting for over 90 percent of export revenues – the country's trade is inevitably sea based. Shipping density in Nigeria's c. 217,000 km² EEZ is high, with several thousand seagoing vessels making port calls along the country's c. 850km coastline each year. Nigeria is also perceived as a regional hegemon in West Africa, taking a 'big brother' role in local affairs typified by past interventions in Liberia and Sierra Leone.

By virtue both of its strategic location and of local socio-economic conditions, oil-rich Nigeria finds itself in the centre of maritime insecurity in West Africa's Gulf of Guinea (GoG).[1] The GoG has long been a hotspot of maritime criminality and is currently regarded as amongst the most dangerous locations in the world for shipping and seafarers. Many of the most serious threats to maritime security originate from the country's unstable Niger Delta region and unfold in – or close to – Nigerian waters. Of necessity, therefore, the Nigerian Navy is the key player in ensuring good order at sea in the wider region, defining its maritime operational area of interest as extending to the GoG's limits. What happens – or does not happen – in Nigerian waters has a pervasive impact on neighbouring countries.

A heavily-armed Nigerian Navy patrol boat pictured at speed during operations in Nigeria's coastal zone. The Nigerian Navy is a key player in ensuring maritime security across much of West Africa's littoral but many of its operations are focused on protecting shipping and infrastructure in unstable coastal and 'brown water' areas. *(Nigerian Navy)*

THE MARITIME SECURITY SETTING

In spite of lingering disputes with neighbours over the delineation of the maritime boundaries, Nigeria currently faces no significant external threat from a rival naval power. Instead, the main challenge is maritime insecurity from criminal activities across Nigeria's littoral zones.

Media attention has tended to focus on militancy in the Niger Delta, violent crime at sea and various forms of theft from the oil sector as the main security problems. Whilst these are significant, there are a myriad of other, often interlinked threats extending from illegal fishing through human trafficking and drug smuggling to environmental pollution. For example, estimates of annual losses from illegal fishing alone in Nigerian waters amount to up to US$1bn each year.

In the majority of cases, however, the root cause of these problems is closely linked to political unrest and wider instability in the oil-producing Niger Delta. Long-standing grievances amongst socio-economically distressed communities experiencing rampant unemployment and enjoying few of the economic benefits of Nigeria's oil revenues have been harnessed by a nexus of organised crime and political interests for nefarious purposes. When combined with high levels of corruption and other aspects of a weak rule

A Nigerian Navy boarding team climbs aboard a target vessel during a training exercise in the Gulf of Guinea in 2015. Securing Nigeria's maritime domain is principally the Nigerian Navy's responsibility, with internal militancy and criminality rather than any external threat the main challenges that it needs to overcome. *(US Navy)*

US Navy sailors work with their Nigerian counterparts to conduct maintenance on a Nigerian Navy Boston Whaler riverine patrol boat in July 2019. The US Navy is one of a number providing 'capacity-building' assistance to the Nigerian Navy but some commentators have argued that a lack of focus on tailoring these programmes to root out corruption has actually fuelled insecurity and crime. *(US Navy)*

of law – as well as inadequate maritime constabulary capabilities – this backdrop has seen many members of coastal localities turn to maritime crime to earn a living. In the words of Dirk Steffen, Head of West Africa Analysis at the Danish-based security consultancy Risk Intelligence, 'Several of these communities have developed considerable skill in conducting seaborne operations, evolving from relatively unsophisticated attacks on static targets to raids against underway vessels, sometimes even including those defended by naval or private security forces'.

Regional maritime crime continues to evolve. Moreover, a detailed assessment of trends is difficult, as the methodology used to report incidents is far from consistent. However, there is an ongoing tendency towards violent attacks and a worrying rise in kidnappings for ransom. The security situation on land, particularly in the Niger Delta, often has a strong influence on the position at sea; for example, heightened levels of militancy or election violence invariably lead to significant changes in threat levels.[2]

Securing Nigeria's maritime domain is principally the Nigerian Navy's responsibility. Other relevant state agencies include the Nigerian Maritime Administration & Safety Agency (NIMASA) and the Nigerian Customs, whilst port security also falls within the ambit of the Nigerian Ports Authority (NPA). The latter often operates in conjunction with the Nigerian Marine Police. They typically take responsibility for inland water areas, an environment in which the Nigerian Army also operates. Many of the oil production companies have long relationships with private maritime security companies (PMSCs), which operate their own vessels to safeguard both infrastructure and shipping. Soon after the turn of the millennium, the Nigerian Navy also entered into collaboration with the PMSCs to operate jointly-crewed security vessels under overall naval control. The bulk of routine patrol and shipping escort operations are conducted under these arrangements.

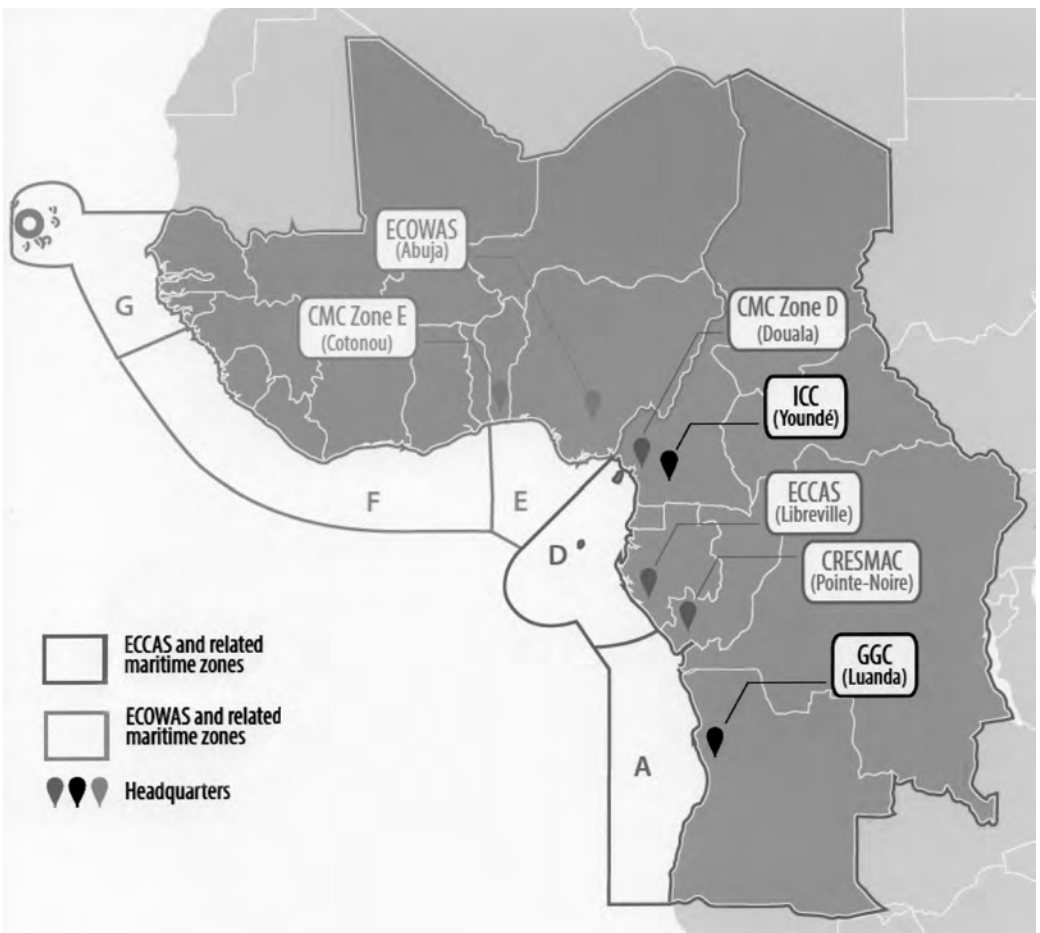
In general terms, the problems of militancy and violent crime emanating from the Niger Delta have proved resistant to attempts at eradication. To those familiar with Nigeria's broader reputation for pervasive criminality and endemic corruption, this will

come as little surprise. The country's system of government has been described as a structured 'kleptocracy' and its armed forces – the navy included – have not proved to be immune. Reports from watchdog organisations suggest that many navy and other security personnel are complicit in activities they are mandated to eradicate. On occasion, it is argued, capacity-building efforts sponsored by international partners can even stimulate criminal activity, allowing corrupt actors in the Nigerian Navy to use newfound skills and improved technology to fuel insecurity and crime.[3]

On the other hand, those familiar with the situation on the ground say that the Nigerian Navy and other agencies are making positive strides in combatting sea-based crime. They note growing awareness amongst junior officers – often trained overseas in Europe and Asia – of the fact that maritime security fosters confidence with international trading partners and supports economic growth. Many are doing what they can to rise to the challenge in the face of limited resources and a sometimes dangerous environment. Two recent procedural and legislative developments are also emblematic of progress. One was the January 2017 launch of the Harmonised Standard Operating Procedures on Arrest, Detention and Prosecution of Vessels and Persons in Nigeria's Maritime Environment. Addressing inter-agency rivalries and minimising overlapping functions, this has helped the navy take the lead in coordinating the fight against maritime crime. The other was the June 2019 passage of a dedicated anti-piracy law; the Suppression of Piracy and Other Maritime Offences Act. This provides a legal framework for prosecuting maritime offenders, bringing Nigeria in line with International Maritime Organisation (IMO) and other standards.

There are also signs of growing international collaboration, with Nigeria often taking the lead in establishing frameworks for regional cooperation in maritime security. The most important is the 2013 Yaoundé Code of Conduct, which aims to foster regional maritime collaboration to repress crime at sea. It was adopted by members of the region's two main economic groupings – the Economic Community of West African States (ECOWAS) and the Economic Community of Central African States (ECCAS) – as well as by those of the overlapping Gulf of Guinea Commission (GGC). Initial progress with information sharing has been slowly followed by more tangible cooperation. Notably, in 2018, a memorandum of understanding was endorsed by Togo, Benin, Nigeria and land-locked Niger for joint patrols in the ECOWAS Maritime Zone E area to be coordinated from a Multinational Maritime Coordinating Centre (MMCC) in Cotonou, Benin Republic. Similar agreements have been put in place in other parts of the area covered by the Yaoundé Code, sometimes supplemented by bilateral arrangements.

A number of recent multinational coordinated responses to rescue hijacked vessels indicate the progress that has been achieved.[4] These have demonstrated a new ability to utilise rapid information sharing to achieve an effective operational response across national boundaries. It is also significant that results have been achieved without the previous reliance on support in areas such as intelligence sharing from countries from outside the region. As



A map of the Gulf of Guinea and surrounds showing the areas covered by the region's two main economic groupings – the Economic Community of West African States (ECOWAS) headquartered in Abuja, Nigeria and the Economic Community of Central African States (ECCAS) headquartered in Libreville, Gabon, as well as the headquarters of the Gulf of Guinea Commission (GGC) in Luanda, Angola. Maritime security in the area is coordinated from an Interregional Coordination Centre (ICC) in Yaoundé, Cameroon whilst there is a Regional Centre for Maritime Security of West Africa (CRESMAO) in Abidjan, Ivory Coast [not shown] and a Regional Centre for Maritime Security of Central Africa (CRESMAC) in Pointe Noire, Congo. A number of separate maritime patrol zones are being established along the coastline, with Nigerian waters falling within ECOWAS Maritime Zone E. Activities in this area are coordinated from a multinational Centre for Maritime Coordination (CMC) in Cotonou, Benin Republic. *(European Union)*

A 'Ford' class seaward defence boat pictured in British waters in the early 1960s prior to delivery to Africa. The Nigerian Navy deployed several of these vessels as part of its decisive role in the Biafran civil war and the designation continues to be applied to some more recent coastal patrol assets today. *(Editor's collection)*

The Vosper Thornycroft Mk 3 corvette *Otobo* pictured during builders trials in 1972. Nigeria ordered two of these ships – both carrying different tribal names for the hippopotamus – at the end of the Biafran conflict. A stream of increasingly sophisticated vessels followed during the years of Nigeria's oil boom. *(Editor's Collection)*

already noted, however, a number of extra-regional players – including the United States, the European Union and many supranational organisations – continue to play an active role building maritime security capacity in the region. For some, these activities are as much a means of safeguarding their own regional political and economic interests as pursuing an altruistic agenda.

All in all, it can be seen that criminal activity, and particularly its deep-seated roots, makes for a very complex maritime security in the GoG region generally and for Nigeria in particular. Whilst the Nigerian Navy has a part to play in achieving a lasting solution, this will ultimately depend on addressing a multitude of issues on land, not just combatting the threat at sea. And cooperation with other regional states in the GoG will be essential given the strong correlation with the maritime security of neighbouring countries.

HISTORY: THE NIGERIAN NAVY'S EVOLUTION

Today's Nigerian Navy traces its origins to colonial era quasi-military Marine Departments which merged into the Nigerian Marine Department – otherwise known as the Nigerian Marine – when the former British protectorates of Southern Nigeria and Northern Nigeria were joined together to form the Colony and Protectorate of Nigeria on 1 January 1914. The Nigerian Marine's focus was largely fixed on providing port safety, security and support services from its inception through to the 1950s, when much of its role was absorbed into the newly formed NPA. However – in part spurred by nationalist pressure in the run up to independence – a small Nigerian Naval Force was created from former Marine Department personnel in April 1956. Subsequently known as the Nigerian Naval Defence Force and then – following formal establishment – the Royal Nigerian Navy, the embryonic fleet followed Nigeria into independence on 1 October 1960. Subsequent early changes saw the removal of the 'Royal' prefix when Nigeria became a republic in 1963. The following year saw the formal establishment of the post-independence navy in its current

form under the Navy Act of 1964. This essentially expanded the navy's role from limited coast guard type duties in territorial waters to those of a fully-fledged naval force.

The Nigerian Naval Defence Force commenced life with eleven small survey, patrol and support vessels inherited from the former Marine Department. These were swiftly reinforced by the transfer of former Royal Navy vessels, including the former *Algerine* class fleet minesweeper *Hare* (renamed *Nigeria*), three seaward defence boats and 'Fairmile B' motor launches, and a tank landing craft. More modern and capable vessels followed during the 1960s, including British 'Ford' class seaward defence boats and a purpose-built flagship – the frigate *Nigeria* – ordered from Dutch shipbuilder Wilton Fijenoord. The former US submarine chaser *PC-468* was also transferred from the Royal Netherlands Navy to serve as an interim training vessel under the name *Ogoja* pending *Nigeria*'s completion. Early reliance on the Royal Navy for training was soon supplemented by support from other nations. Notably, extensive cooperation with the Indian Navy in the early 1960s saw many senior staff posts and warship commands assumed by seconded Indian Navy officers. The fleet's principal operating base was at Apapa in the then capital of Lagos, with facilities in the east largely used by ships on temporary 'eastern patrols' until a reorganisation in the early 1980s.

The navy's early development was interrupted by the ousting of Nigeria's civilian government in 1966 and a series of bloody tribal clashes that resulted in the Ibo people of south-east Nigeria attempting to secede from the Nigerian Federation as the Republic of Biafra. The civil war that followed between 1967 and 1970 saw the Nigerian Navy mount an effective sea blockade on the new republic that played a significant part in the conflict's eventual outcome, albeit at the cost of up to as many as three million civilian fatalities from starvation. The navy suffered the capture of the 'Ford' class seaward defence vessel *Ibadan* (ex-HMS *Montford*) by Biafran forces at the start of the war but received new ships from both British and Soviet sources. *Ibadan* – renamed *Vigilance* – was destroyed in the course of an amphibious operation to seize the entrance channel to the major oil transhipment facilities at Port Harcourt. These operations were subsequently extended to encompass the remainder of Biafra's coastline, further accelerating Biafra's eventual collapse. The veteran *Ogoja* played a key part in these operations, only to be lost by grounding towards the end of the war.[5]

Delivered in 1981, *Aradu* was the very first MEKO frigate and the most sophisticated warship ever operated by Nigeria. Nominally assigned to the navy's Western Command headquartered at Lagos, she has not been operational for several years and is currently under repair at Naval Dockyard Lagos. This picture was taken during a flag-showing visit to Brazil in 2007. *(Alexandre Galante)*

The conclusion to the conflict brought about a largely successful period of national reconciliation and an economic boom resulting from increasing oil revenues. Two 62m Vosper Thornycoft Mk 3 corvettes – *Dorina* and *Otobo* – ordered towards the end of the civil war were followed by a stream of increasingly sophisticated vessels as part of a plan to ensure protection of the country's offshore oil infrastructure. Key acquisitions included the Vosper Thornycroft Mk 9 corvettes *Erinomi* and *Enyimiri*; two three-strong batches of missile-armed fast attack craft; two tank landing ships; and a series of large patrol vessels. Perhaps the most impressive acquisition however was the MEKO 360 frigate *Aradu*, first of the MEKO series of modular designs and possibly the most sophisticated surface combatant in the continent at the time. By the mid-1980s, a nascent naval air arm had also been created with the purchase of three Lynx Mk 89 helicopters whilst two *Lerici* type minehunters provided a modern mine countermeasures capability. Base infrastructure was also expanded and operational vessels divided between a Western Fleet located at Apapa and an Eastern Fleet headquartered at Calabar.

On paper this provided a formidable force but one which, unfortunately, did not translate into a commensurate operational capability. By the early 1990s, only a few of these complex and expensive vessels were operable as a result of a combination of poor maintenance, funding problems and human issues such as apathy and indiscipline. Problems were also exacerbated by continued political infighting and international sanctions against the country's military dictatorship before the country's return to civilian rule in 1999. Nevertheless, the navy played an active role alongside the other branches of Nigeria's armed forces in supporting regional stabilisation missions, notably in Liberia and Sierra Leone. These deployments – conducted under the auspices of the multinational but Nigerian-dominated Economic Community of West African States Monitoring Group (ECOMOG) – were evidence of Nigeria's ongoing ambition to play a dominant military and political role in ensuring stability across the West African region.

The start of the current millennium saw the Nigerian Navy at a low ebb, with few of its major ships operational. A number of the major platforms acquired over the previous decades were decommissioned and scrapped. However, the last decade has seen an uptick in the navy's fortunes with the acquisition of numerous new platforms ranging from OPV-like 'frigates' to small riverine patrol craft under the auspices of the Nigerian Navy Transformation Plan (NNTP) 2011–2020.[6] Whilst these acquisitions have helped improve overall availability, sustainment remains an uncertain factor given previous efforts to refit ships at the naval dockyard in Lagos have achieved distinctly mixed results.

CURRENT ORGANISATION AND STRUCTURE

The Nigerian Navy is headed by the Chief of Naval Staff (CNS), currently Vice Admiral Ibok-Ete Ekwe Ibas. He is the navy's longest-serving CNS to date, having assumed office in July 2015. Based at Nigerian Naval Headquarters in Abuja, the CNS is assisted by nine Branch Chiefs of flag rank responsible for (i) Policy & Plans; (ii) Training & Operations; (iii) Naval Engineering; (iv) Logistics; (v) Accounts & Budget; (vi) Naval Safety & Standards; (vii) Administration; (viii) the Office of the Navy Secretary; and, since 2015, (ix) the Nigerian Navy Transformation Branch. Each branch is, in turn, comprised of several directorates. There are also a number of separate offices that report directly to the CNS. In general terms, the number of headquarters branches has increased over time.

Reporting to Nigerian Naval Headquarters are three operational and two functional commands headed by Rear Admirals and three separate autonomous units.

Operational Commands: The operational commands are the Western Naval Command (WNC) headquartered at Apapa, Lagos; the Eastern Naval Command (ENC) at Calabar near the border with Cameroon; and the Central Naval Command (CNC) at Camp Porbeni, Yenagoa in the Niger Delta region. The latter command was established in 2012 and its headquarters are due to be shifted to Brass on the coast but this move has yet to be implemented. Each Naval Command has a geographically-defined area of responsibility (AOR) and controls the major operations bases, forward operating bases, naval air facilities and other infrastructure in its territory. The vessels assigned to each command vary according to operational need, although the larger warships tend to be assigned to the more-established WNC and ENC by dint of their control of the necessary support infrastructure. In practice, the large fleet of assorted armed vessels operated by PMSCs under naval command and control provide the bulk of operationally available patrol craft.

The WNC's main facilities are clustered in the Lagos area, although there are other operations bases and forward operating bases in its AOR. Protection of the port and oil storage infrastructure in the Lagos metropolis – an area home to as many as 20 million people – rank amongst its main responsibilities. Although the ENC is headquartered at Calabar, many of its facilities are focused on the oil production infrastructure around Port Harcourt and its approaches, including the important facilities at Bonny and Onne. Its AOR has been estimated to encompass around eighteen oil and gas production terminals, over 500 oil fields, two refineries, three major sea ports and production infrastructure spread across nine major rivers and over 5,000 creeks and estuaries. The CNC's AOR also encompasses significant oil production infrastructure and its permanent facilities are supplemented – as in the other commands – by a number of floating naval security stations. These are deployed as mobile checkpoints in the Niger Delta region, where oil theft is rampant.

Seen here at the time of her formal commissioning in December 2016, *Karaduwa* is the second locally-built seaward defence boat completed at Naval Dockyard Lagos. Next to *Karaduwa* is a locally-built tug *Cdr. Ugwu*, which was built at the Naval Shipyard in Port Harcourt. Both facilities are managed by Nigerian Navy Holdings Limited, an autonomous unit within the navy's organisational structure. *(Nigerian Navy)*

Logistics Command: Headquartered in the Oghara Township near Sapele in the Delta State, the command has four depots in Lagos, Calabar, Port Harcourt and in Sapele itself that are responsible for supplying materiel and fuel to the navy's bases and fleet. The command also controls three Fleet Support Groups based in Lagos (FSG West), Calabar (FSG East) and Warri (FSG Central) that work with the three operational commands. Other assets include a Motor Vehicle Maintenance Group and a Helicopter Support Group, both located in Lagos.

Naval Training Command: First established in the mid-1980s, the Naval Training Command (NAVTRAC) is headquartered at Apapa. Responsible for the coordination and harmonisation

The Nigerian Navy currently operates around thirty-five active sea-going vessels, of which the two P-18N corvettes delivered from China in 2014 and 2016 are the most capable. This picture shows lead ship *Centenary* during the Obangame Express exercises in 2019. *(Portuguese Air Force via Dirk Steffen)*

of training doctrines and standards for all Nigerian naval training, its principal units include:

- The Sea Training Unit, Victoria Island, Lagos: Undertakes operational and safety training, as well as harbour and ship acceptance trials of vessels after major refits.
- NNS Quorra at Apapa: Provides professional courses for officers and ratings.
- Nigerian Navy Engineering College at Sapele: Responsible for technical training for all navy technical personnel. The hulk of the former frigate *Nigeria* – renamed *Obuma* in 1981 – forms part of this establishment.
- Nigerian Navy Finance and Logistic School at Owerrinta, north of Port Harcourt.
- Nigerian Naval College and the Nigerian Navy Basic Training School (NNBTS), co-located at Onne, Port Harcourt: Conduct basic training for officers and ratings, respectively.

There are also other professional training schools encompassing disciplines ranging from medicine and music through to naval intelligence and hydrography. Comparatively recent developments include the establishment of a Joint Maritime Security and Training Centre as part of a British capacity-building initiative launched in 2008 and the modernisation of the Nigerian Navy's Underwater Warfare School under a public private partnership (PPP) arrangement with the Mieka Dive Training Institute (MDTI) in 2011. Subsequently, in 2017, a Naval War College Nigeria – the premier naval training institution in Nigeria – was commissioned at a temporary site in Ubima Rivers State. In 2019, a Maritime Domain Awareness Training School equipped by the US Navy, was opened in Apapa as a regional training centre.

Autonomous Units: These encompass (i) the Naval Ordnance Depot; (ii) the Naval Doctrine and Assessment Centre and; (iii) Nigerian Navy Holdings Limited. The ordnance depot stores munitions for various branches of the armed forces whilst Nigerian Navy Holdings manages a range of business enterprises including the Naval Dockyard Limited at Wilmot Point on Victoria Island in Lagos and the Naval Shipyard Limited in Port Harcourt on the navy's behalf. The two yard facilities, which used to be autonomous units in their own right, perform maintenance and modernisation of navy ships as well as some shipbuilding projects. In general terms, the dockyard is responsible for major work on the fleet's larger ships whilst the shipyard maintains smaller vessels and also performs commercial work.

Special Boat Service: Established in 2006, the Nigerian Navy's Special Boat Service (SBS) is modelled on its British Royal Navy equivalent as well as similar units such as the US Navy's SEALS. Based at Navy Town Ojo in Lagos, the unit is understood to comprise 300–400 personnel. Focused on counter-terrorism, insurgency and piracy operations as well as other littoral and riverine operations, it has been intensively deployed in support of internal security operations. It has also engaged in training similar units established by other West African nations. Observers who have exercised with the SBS on multinational exercises say that they are the best trained of the West African Special Forces.

CURRENT EQUIPMENT

With some 25,000–30,000 personnel, the Nigerian Navy is estimated to operate around thirty-five active seagoing vessels and over 350 coastal and riverine craft. Current major equipment is listed in

Table 2.3A.1: NIGERIAN NAVY – PRINCIPAL UNITS AS AT MID 2020[1]

TYPE	CLASS	NO.	YEAR[2]	TONNAGE	DIMENSIONS	SPEED	PRINCIPAL ARMAMENT
Frigates (3)							
Frigate (FFG)	**ARADU** (MEKO 360)	1	1982	3,500 tons	126m x 15m x 4m	30+ knots	8 x SSM, 1 x octuple SAM, 1 x 127mm, 4 x twin 40mm, 6 x TT, 1 x helo
Frigate (FF)	**HAMILTON** (WHEC-175)	2	1967	3,250 tons	115m x 13m x 5m	29 knots	1 x 76mm, 1 x helo, light weapons
Aradu – along with many of her weapons systems and elements of her propulsion plant – is non-operational pending completion of refit.							
Corvettes/OPVs (7)							
Corvette (FF)	**CENTENARY** (P-18N)	2	2014	2,000 tons	95m x 12m x 4m	20 knots	1 x 76mm, 2 x 30mm, 1 x helo
Patrol Vessel (OPV)	**EMER** (P21)	1	1978	1,200 tons	65m x 11m x 4m	17 knots	1 x 40mm
Patrol Vessel (OPV)	**CACTUS** (WLB-270)	4	1942	1,000 tons	55m x 11m x 4m	13 knots	Light weapons
The sole P21 class vessel in commission is known as *Prosperity*. The four *Cactus* class patrol vessels are known as the 'Cat' class locally.							
Fast Attack Craft/Patrol Vessels (3)							
FAC	**EKPE** (FPB-57)	1	1980	450 tons	58m x 8m x 3m	40+ knots	1 x 76mm, 2 x twin 40mm, 2 x twin 30mm
FAC	**SIRI** (Combattante IIIB)	2	1981	425 tons	56m x 8m x 2m	38+ knots	1 x 76mm, 2 x twin 40mm, 2 x twin 30mm
Possibly one *Ekpe* class vessel and one/two *Siri* class vessels operational. The original missile systems and some other weapons systems on the vessels that are in service are probably inoperative.							
Mine Countermeasures Vessels/Patrol Vessels (2)							
MCMV		2	1985	550 tons	51m x 10m x 3m	16 knots	1 x twin 30mm, 2 x 20mm
The two ships' mine-hunting equipment is inoperative, leaving them only capable of functioning as patrol ships.							
Seagoing Patrol Boats (c.20)							
PB	**ZARIA** (Sea Eagle Mk II)	2	2009	200 tons	38m x 7m x 2m	25 knots	Light weapons
PB	**NGURU** (FPB 110)	2	2018	175 tons	35m x 7m x 2m	28 + knots	Light weapons
PB	**DORINA** (FPB 98)	1	2013	150 tons	32m x 6m x 2m	30+ knots	Light weapons
PB	**OKPOKU** (FPB 72)	8	2012	125 tons	24m x 6m x 2m	32+ knots	Light weapons
PB	Shaldag Mk II	4	2009	60 tons	25m x 6m x 1m	45 knots	Light weapons
There are also two locally-manufactured seaward defence boats – the 31m *Andoni* and the 39m *Karaduwa*, as well as the 46m Chinese-built *Sagbama*. A further indigenous SDB as well as two further FPB 110 are believed to be amongst a number of patrol vessels that will be delivered soon.							
The above vessels are supplemented by large numbers of inshore and riverine patrol vessels less than 20m in length. Please refer to the text for further details.							

Notes:

1. Given doubts over the status of many Nigerian Navy ships and limited transparency, this table is more than usually speculative.

2. Date relates to the date the first ship of the class entered service, sometimes with a foreign navy. In some cases, these ships are now retired.

Table 2.3A.1. Given considerable difficulties identifying which assets are in operational use, some data and analysis is inevitably speculative.

Principal Units: The Nigerian Navy's flagship – the 1980s' vintage MEKO 360 frigate *Aradu* – has not been used operationally for a decade or so. Since late 2018 she has been under refit at the Naval Dockyard, Lagos so may return to active service, possibly as a training vessel, in the foreseeable future.

The two 95m P-18N offshore patrol vessels (OPVs) built by the Wuchang shipyard in Wuhan are probably the navy's most capable assets. Based on China's Type 056 corvette design, the two ships are relatively lightly armed with a 76mm main gun and lighter calibre weapons but are aviation capable. The lead ship, *Centenary*, was delivered in China on 27 November 2014 but handover of the second vessel, *Unity*, was delayed until September 2016 because of propulsion system defects.

The navy's two former US Coast Guard *Hamilton* (WHEC-175) class high endurance cutters *Thunder* (ex-*Chase*) and *Okpabana* (ex-*Gallatin*), are now over 50 years old but have proved to be useful platforms since transfer in 2011 and 2014. Classified as frigates by Nigeria, they are also aviation capable. *Thunder* made the longest-ever voyage for a Nigerian warship when visiting Australia for the International Fleet Review at Sydney in 2013.

Other significant warships include the former Irish Naval Service OPV *Prosperity* (formerly *Emer*), which was initially acquired as a private security vessel but subsequently commissioned into the navy as a sea training vessel in 2015. The four elderly US Coast Guard *Cactus (*WLB-270) class buoy tenders dating from the Second World War known locally as

The 'frigate' *Okpabana* – formerly the US Coast Guard high endurance cutter *Gallatin* (WHEC-721) – is one of two of the class transferred in 2011 and 2014. In spite of being over 50 years old, they have proved to be useful assets. *(Nigerian Navy)*

the 'Cat' class have proven to be robust platforms, having a good record of service because of their simplicity and ease of maintenance. At least three of the four ships – *Kyanwa*, *Ologbo*, *Nwamba* and *Obula* – are thought to be operational.

The two Intermarine-built *Lerici* class mine-hunters – *Barama* and *Ohue* – and possibly three of the six Lürssen FPB-57 and CMN 'Combattante IIIB' fast attack craft complete the roster of major seagoing assets. All are employed as patrol vessels given the equipment for their original roles has been non-operational for decades.[7]

Seagoing Patrol Forces: A number of seagoing patrol vessels, sometimes referred to locally as seaward defence boats (SDBs), complement the larger vessels. These include the first two locally-built SDBs *Andoni* and *Karaduwa*, which were commissioned in 2012 and 2016. A third SDB is under construction. The larger 46m *Sagbama* – sometimes reported as locally-built – was donated by China as part of the P-18N acquisition. There are also two older Malaysian-built 'Sea Eagle' Mk II patrol vessels – *Burutu* and *Zaria* – acquired under a contract with Singapore-based Suncraft International Group and both commissioned in 2009.

The most numerous patrol assets, however, are a series of high-speed aluminium-hulled vessels supplied by French company OCEA between 2012 and 2019. They comprise the two 35m FPB110 Mk II designs *Nguru* and *Ekulu* delivered in 2018; a single 32m FPB 98 Mk I hull *Dorina* acquired in 2013; and eight 24m FPB 72 Mk I and Mk II vessels – *Badagry*, *Bomadi*, *Okpoku*, *Gongola*, *Calabar*, *Shiroro*, *Ose* and *Osun* – supplied between 2012 and 2019. One of the FPB 72 Mk II boats, *Calabar*, is currently at the Naval Dockyard awaiting hull repairs after making contact with a submerged wreck in the Lagos channel in 2019. It is understood that two additional FPB 110 Mk IIs are either under construction or in the course of delivery.

In addition to the OCEA-built craft, four 25m Shaldag Mk II gun-armed fast attack craft – *Onitsha*,

The Nigerian Navy's four *Cactus (*WLB-270) class buoy tenders were first completed for the US Coast Guard in the course of the Second World War and are now amongst the oldest operational warships in the world. However, their simplicity and ease of maintenance mean that they have proved far more robust than many more modern and sophisticated vessels in Nigerian service. This is *Nwamba* – formerly *Firebush* (WLB-293) – at Rio de Janeiro in 2007. *(Alexandre Galante)*

Benin, *Ikot Abasi* and *Ibusa* – were acquired from Israel Shipyards between 2009 and 2013.[8]

Inshore Patrol and Riverine Forces: The Nigerian Navy has a significant fleet of fast interceptors generically known as the 'Manta' class. Most of these comprise 17m 'Manta' Mk II ASD hulls designed by the late Otto Ranchi and procured from Suncraft. At least nine had been acquired by 2012 and subsequent deliveries have taken the total number of vessels to around twenty. An eclectic mix of other vessels includes the remnants of numerous small craft – some tied up alongside, some ashore – purchased during the acquisition spree of the early 1980s.

The navy also operates a sizeable force of rigid-hulled inflatable boats, with over ninety such craft having been acquired between 2015 and 2020 according to a May 2020 Nigerian Navy brief. Around thirty-five of these have been built by Nautic Africa and others supplied by Sillinger and Suncraft through Malaysian and Polish sub-contractors.

The need to patrol Nigeria's vast, often lawless creeks and estuaries in the Niger Delta and elsewhere has resulted in the deployment of a growing fleet of riverine patrol craft known locally as 'gunboats'. The most numerous type of 'gunboat' in service is an 8m GRP-hulled design supplied by Port Harcourt-based Epenal. Powered by twin outboards for a top speed of c. 35–40 knots, they are typically fitted with machine guns and grenade launchers. It appears that many of these craft have also been built under licence in naval facilities and by other suppliers. A number are used for naval hydrographic duties. Other manufacturers – including America's Boston Whaler and Safeboats – have supplied similar small boats to the navy and the other armed forces.

Since 2016, the Nigerian Navy has also been introducing the naval security station 'houseboats' referenced above, which act as mobile bases for gunboats in areas where crude oil theft and illegal refining activities are known to be prevalent. Over thirty of these bases are eventually planned. It is also worth noting that the Nigerian Army operates large numbers of small landing craft and patrol boats in support of its own riverine security operations.

Nigerian Naval Air Arm: The navy controls a small air arm currently believed to comprise six AW109E Power, two AW139 and two AB 206 helicopters, the last-mentioned used for training. Only around four to five helicopters are usually operational and attrition is high, with three AW109Es being written off since the type was inducted. The main air station is Naval Air Base Ojo in Lagos. Other facilities include Naval Air Station Effurun near Warri and a Naval Flying Unit at Port Harcourt.

Three navy-operated AW109 GrandNew 'special mission' helicopters acquired under the Deep Blue project described below are expected to enter service in early 2021. A further three AW139s will also arrive before the end of 2021. Consideration has also been given to acquiring surplus Lynx Mk 8 sea control helicopters but the status of this project is currently uncertain.

Coastal and riverine assets form by far the largest proportion of the Nigerian fleet strength. Prominent amongst these are so-called 'gunboats' – fast, shallow-draught rigid hulled designs armed with machine guns and grenade launchers that are increasingly produced by local manufacturers such as Port Harcourt-based Epenal. *(Nigerian Navy)*

MARITIME DOMAIN AWARENESS

The Nigerian Navy's seagoing vessels and helicopters are supported by the most extensive multi-agency coastal surveillance coverage in West Africa. This capability is provided by a combination of Nigerian Navy, NIMASA and NPA assets.

The core of surveillance coverage comprises two complementary systems operated by the navy. One is the US-funded Regional Maritime Awareness Capability (RMAC); the other the Israel-supplied Falcon Eye system that covers RMAC's blind arcs. RMAC – first installed between 2007 and 2009 – is part of a continent-wide initiative integrated into the global Maritime Safety and Security Information System. Falcon Eye is a subsequent national initiative inaugurated in 2016. Together the two systems provide a network of static radar and electro-optical sensors supplemented by a number of mobile surveillance systems linked to control centres at Naval Headquarters and in the three operational commands.

The two navy systems will be supplemented by a new coastal surveillance system that is being developed under NIMASA's leadership in the form of the Deep Blue project. An inter-agency programme with substantial involvement from the Nigerian Navy, other branches of the armed forces and the police, it is being delivered in conjunction with Israeli company Blue Octagon. The project was formally authorised in 2018. It comprises a range of surveillance and interception vessels; special mission manned and unmanned aircraft; vehicles; and surveillance sites that exchange information with each other and a central command centre by

extensive data links. Described as creating a multi-layered security grid, the project appears to encompass many coast guard-like functions and the precise way its assets will both be shared and also interface with existing Nigerian Navy operations is not entirely clear. However, in spite of the usual challenges, efforts are reportedly well underway to integrate the Deep Blue system into the existing naval surveillance infrastructure. The NPA also operates its own port surveillance systems and moves are afoot to link it into the wider intelligence network in due course.[9]

Additionally, Nigerian Air Force-operated ATR-42, Super King Air 350 and DA-42 aircraft also provide a useful maritime patrol and information gathering capability. These will be bolstered by two new Cessna CJ-3 maritime patrol aircraft acquired under the Deep Blue initiative.

PRIVATE MARITIME SECURITY COMPANIES

An ongoing feature of Nigerian Navy operations has been the use of PMSCs to supplement navy efforts to protect shipping and related infrastructure. This practice commenced early in the new millennium and has become increasingly formalised, largely through the agreement of memoranda of understanding between the navy and the various PMSCs. Nigeria has steadily moved to prohibit the embarkation of private security contractors on merchant ships entering its waters. Instead current arrangements typically provide for privately-owned and crewed security vessels to provide escort services under navy control with embarked Nigerian Navy personnel, who are responsible for operating shipboard weapons. Around 130 or so vessels are involved in security activities on a full or part-time basis, with around thirty companies having authorised status with the naval authorities. The largest of these is Ocean Marine Solutions Ltd (OMS), which operates in the region of forty largely-purpose-built patrol vessels with temporary naval pennants.

The role of PMSCS in supporting Nigerian maritime security is somewhat controversial. Not all security firms are equally capable and there can be significant variations in the quality of the vessels providing the service. There have therefore been criticisms of both the high costs and poor quality associated with some service providers, as well as allegations that the less professional players often serve to foster corruption. It has even been cynically suggested that '… there is a risk that [the model] reduces the incentive to reduce the piracy threat, as a reduction … would be bad for business'.[10] However, the Nigerian model of private companies providing security vessels, partly manned by naval personnel, is unlikely to change in the foreseeable future despite comments to the contrary from NIMASA.

The Nigerian Navy's *Prosperity* – formerly the Irish Naval Service's *Emer* – was originally acquired by commercial interests to operate for one of the private maritime security companies that provide escort vessels to merchant shipping under naval control. Following acquisition by the navy, she now largely operates as a training vessel. *(Nigerian Navy)*

STRATEGY AND FUTURE PLANS

The Nigerian Navy's future direction is currently driven by its Total Spectrum Maritime Strategy (TSMS), which was first articulated as far back as 2012. The strategy calls for the flexible application of naval power over five different spectrums encompassing:

- **Spectrum 1:** This essentially covers 'brown water' operations along inland waterways up to including the coast and in ports and other associated infrastructure. The focus is on combatting insurgency, sabotage and economic crimes through choke-point management, active riverine sweeps and the protection of shipping, ports and oil and gas installations.
- **Spectrum 2:** This is comprised of the 'green water' area from the coastline to the 12 nautical mile limit of Nigeria's territorial waters. As well as a continued focus on infrastructure and resource protection, the main priorities here are combatting illegal activities and potential terrorism. Although the navy is increasing its presence in territorial waters, the continued reliance on the PMSCs given continued shortages of patrol assets is regarded as essential.
- **Spectrum 3:** This corresponds to Nigeria's EEZ, with core objectives broadly similar to those outlined for Spectrum 2. The active use of the navy's few 'capital ships', alongside collaboration with neighbouring navies, are regarded as key enablers.
- **Spectrum 4:** This area extends throughout the GoG and West Africa, being considered Nigeria's outermost area of maritime interest. The navy's

A new Damen LST100 tank landing ship is one of the few large vessels planned for delivery to the Nigerian Navy in the immediate future. An order for a second vessel seems likely in due course. *(Damen)*

involvement in regional expeditionary operations – most recently the ECOWAS Operation Restore Democracy in Gambia – is regarded as emblematic of its role in this spectrum.

- **Spectrum 5:** This relates to internal security operations – often in conjunction with other branches of the armed forces – in the 'aid to the civil power' category.[11]

In general terms, improving capacity to conduct operations in Spectrums 1, 2 and 5 appear to be the navy's top priorities and are reflected in future procurement plans. This will be achieved by pursuing a so-called 'Trinity of Action' encompassing (i) surveillance (i.e. maritime domain awareness), (ii) response (i.e. interdiction) and (iii) law enforcement capabilities. The priority being attached to the Deep Blue project can be viewed in the light of the first two elements of this trinity, whilst the new harmonised standard operating procedures and the piracy law reflect the importance given to enforcement.

The practical means of implementing the TSMS is the R-NNTP 2011–2020 Transformation Plan, more recently supplemented by the navy's new ORBAT 2017 to 2026. In essence, the plan attempts to guide change along certain lines of development, of which fleet renewal, logistics and capacity building (encompassing both infrastructure and human resources) appear to be central. Aside from platform procurement, the improvement of base facilities at Lagos and Calabar, expansion of the air arm base at Ojo, the realisation of new and improved forward operating bases and the creation of a modern VHF communications network are all tangible signs of progress. However, significant challenges remain. For example, the two naval yards still lack modern equipment, whilst a shortage of accommodation means that less than half the navy's sailors are housed in naval barracks.

Acquisition plans for new vessels – particularly in the longer term – are difficult to assess with precision as only limited information is released into the public domain and intentions are often opaque. Whilst the R-NNTP called for a major programme of procurement ranging from frigates downwards, only a small part of this aspiration has been realised. For the present, short-term procurement would appear to be focused on the coastal and riverine vessels needed to meet Spectrum 1 and 2 objectives, with two major exceptions.

One is the construction of a new Damen LST100 tank landing ship suitable for regional expeditionary operations that was subject to a keel-laying ceremony at the company's yard in Sharjah, UAE in December 2019. The vessel has a helicopter/UAV deck and significant space for cargo, loaded with the stern ramp, bow ramp or the 25-ton main crane. A military force of up to 250 personnel can be embarked. Previous official documents suggest a requirement for two tank landing ships so an additional vessel seems likely in due course. The other – which will have use both in coastal waters and across the wider EEZ – is a new 60m OSV 190 hydrographic survey vessel from OCEA that will replace the former British-built *Bulldog* type *Lana*. The new vessel will be similar to the *Rigel* and *Spica* previously delivered to the Indonesian Navy.

The OCEA 35m FPB 110 type fast patrol boat *Nguru* pictured off the Nigerian coast in 2019. The French company has become one of the Nigerian navy's suppliers of choice, delivering over ten coastal patrol boats in the last decade. Further patrol boats and a hydrographic survey ship are either under construction or in the course of delivery. *(Portuguese Air Force via Dirk Steffen)*

Other current acquisitions encompass a wide range of brown and green water assets. The relationships with Damen and OCEA are understood to extend to deliveries of further fast patrol vessels in the 35m/40m categories and the latter company is also reported to have a contract to supply four of its C-Falcon fast interceptors. Construction of the third SBD at the Naval Dockyard will probably be followed by additional ships of steadily increasing capability. Ongoing acquisitions of 'Manta' type inshore patrol vessels, Epenal-designed gunboats and various RHIBs for coastal and riverine operations also seem likely.

CONCLUSION

The Nigerian Navy is essentially a constabulary force focused on riverine and coastal operations. The last decade has seen some progress in regaining capabilities lost after the boom years of the 1980s came to an abrupt end and a limited capacity to exert maritime influence in the country's EEZ and wider sphere of influence across the GoG has been restored. The moves to improve overall maritime domain awareness and expand collaboration with neighbouring countries are particularly encouraging. Some tangible successes in the form of the interdiction and apprehension of criminals have been achieved.

In spite of this progress, massive challenges remain. The fact that the GoG remains a global hotspot for maritime crime, for example accounting for 90 percent of all reported global kidnappings at sea in 2019, is clear evidence that the navy's capacity remains inadequate. Notably, poor infrastructure and limited logistical support continue to hamper operational availability. Moreover, a bloated naval bureaucracy and inflated rank system – it is believed there are at least 50 admirals and 100 commodores in the navy's hierarchy – rewards political connections over merit and prevents the creation of a truly professional force. The PMSCs go some way to mitigating capacity shortfalls but are very much a two-edged sword.

The politics of maritime insecurity in Nigeria are anything but simple, with deep-rooted problems such as endemic unemployment, social injustices and systemic corruption all playing a major part. Whilst there are strong commercial imperatives driving recent improvements, these problems will need to be overcome if Nigeria is to develop the navy that it needs.

Notes

1. Rich in undersea resources – principally hydrocarbon deposits, minerals and fish stocks – the GoG is critical to regional maritime commerce. Geographically, the International Hydrographic Organization defines the region as extending from the borders of Côte d'Ivoire (Ivory Coast) and Liberia south eastwards to northern Gabon. However, from a maritime security context the GoG falls within the interest of two political and economic state groupings; the Economic Community of West African States (ECOWAS) and the Economic Community of Central African States (ECCAS). In 2013, these organisations joined another regional intra-state organisation – the Gulf of Guinea Commission (GGC) – to agree the Yaoundé Code of Conduct.

2. These comments are based on remarks by Dr Dirk Siebels, a Senior Analyst at the Risk Intelligence consultancy. Dr Siebels explains that threats in the GoG constantly evolve. Various factors such as weather conditions, traffic patterns and ongoing naval operations come into play. For example, during Nigeria's rainy season (from April to September), it is hard to use speedboats offshore so attacks are fewer and close to land. During the dry season (from October to March), there are more attacks and these can be further out to sea. Understanding these patterns of attacks are necessary to identify threats and for maritime domain awareness. The author thanks both Mr Steffen and Dr Siebels for their considerable help with these and other insights. All opinions expressed remain the author's own.

3. For example, see Åse Gilje Østensen, Sheelagh Brady and Sofie Arjon Schütte of the U4 Anti-Corruption Resource Centre's, *Capacity building for the Nigerian Navy: Eyes wide shut on corruption* (Bergen: Chr. Michelsen Institute, 2018). Their report – available by searching www.u4.no – argues that the Africa Partnership Station (APS) and Africa Maritime Law Enforcement Partnership (AMLEP) programmes sponsored by the US Africa Command has professionalised corrupt actors in the Nigerian Navy by building capacity whilst ignoring the problem.

4. One good example is the successful interdiction and apprehension by the Nigerian Navy of the criminals who hijacked the Chinese-flagged fishing vessel *Hailufeng 11* off Ivory Coast in May 2020. The vessel was tracked and recaptured through the coordinated efforts of several GoG navies – Côte d'Ivoire, Ghana, Togo, Benin and Nigeria – utilising the regional maritime security coordination centres established under the Yaoundé Code to share information rapidly. See Ian M Ralby's article, 'Nigerian Navy Thwarts Hijacking of Chinese Fishing Vessel' posted to *The Maritime Executive* website – www.maritime-executive.com – on 17 May 2020.

5. For more detail of the Nigerian Navy's role in the Biafran War see William Abiodun Duyile, 'Nature and Impact of Involvement of the Navy in the Nigerian Civil War, 1967-1970', posted to the *International Journal of Naval History* website – www.ijnhonline.org – on 17 November 2016.

6. Covering the period 2011–2020, the NNTP was initially released in December 2011. It was updated in August 2014 as the Revised Nigerian Navy Transformation Plan (R-NNTP) 2011–2020. More recently, a new navy new ORBAT 2017–2026 has been agreed that appears to build further on the previous plans.

7. Sources differ on the status of the former fast attack force. The FPB-57 *Ekpe* and the Combattante IIIBs *Ekun* and *Siri* are believed to have completed refits in 2017. *Ekun* and *Ekpe* were confirmed to be in service as of early 2020.

8. Some sources suggest a fifth vessel was also acquired.

9. The Deep Blue project is officially known as the Integrated Security and Waterways Protection Infrastructure. It largely replaces former efforts to create an essentially privatised coast guard-like organisation under NIMASA's Maritime Guard Command that appear to have been abandoned as a result of changes in political influence. The new arrangement appears to revert to the previous practice of using navy vessels and personnel to perform the Maritime Guard Command's operational functions.

10. This quote was attributed to Jakob Larsen, head of maritime security at the Baltic and International Maritime Council shipping association in an Agence French Presse article 'West Africa grapples with piracy in Gulf of Guinea hotspot' posted to the *Hellenic Shipping News Worldwide* website – hellenicshippingnews.com – on 9 January 2020. For further analysis on the development of the PMSC sector, see Dirk Steffen's article, Gulf of Guinea Maritime Security in 2016 posted to the *Center for International Maritime Security* site – cimsec.org – on 11 April 2017.

11. Further detail on Nigeria's naval strategy, achievements to date and the challenges yet to be overcome were provided in a CNS Briefing Note, 'Brief for the Senate Committee on Navy on the Operational Activities of the Nigerian Navy during familiarisation visit to the Navy Headquarters on 18 December 2019' posted to the navy's website – www.navy.mil.ng – on that date. The navy's official magazine, *The Sailor*, which is also available on the site provides additional insights.

2.4 REGIONAL REVIEW

EUROPE AND RUSSIA

Author:
Conrad Waters

Early in 2020, Hervé Guillou – the retiring head of France's Naval Group – gave several statements about the state of the European warship construction sector. M. Guillou has been a leading proponent of transnational consolidation during his six years holding Naval Group's top job and a driving force behind the strengthened partnership with Italy's Fincantieri. In January 2020, the Navaris joint venture between the companies became fully operational. Initially aimed at strengthening collaboration in areas such as R&D, procurement and export promotion, it is clear that the two companies – and their sponsoring governments – hope the entity will be a vehicle for further European integration.

The drivers for European consolidation are clear. The global landscape of warship construction has changed dramatically since the turn of the millennium. New Asian entrants such as China, South Korea, Singapore and India have become competitors for a finite number of construction contracts. As noted by M. Guillou, the shift in naval power and, thus, spending eastwards has also meant that Europe has become increasingly dependent on export contracts: 'Not one European domestic market is sufficiently large, including the French market, to maintain the skills and levels of competitivity which we currently enjoy.'[1]

The inaugural, 'flagship' project for the hoped-for consolidation is the European Patrol Corvette (EPC). This has been initiated by France and Italy within the framework of the European Union's (EU's) 2017 Permanent Structured Cooperation (PESCO) initiative and is expected to be the first shipbuilding project undertaken by Navaris.[2] Reports suggest the EPC will be a c. 3,000-ton vessel designed with a modular approach. This will allow the ship to be configured to perform a variety of roles according to the needs of participant nations. Italy is the EPC project coordinator and has a need for eight ships, whilst France is said to require between nine and eleven. Greece quickly signed up for the programme and has subsequently been followed by Spain. This effectively brings Navantia into the project's industrial infrastructure, advancing the underlying strategic aim.

There are, however, considerable challenges to the dream of a wider consolidation of the European naval sector being realised. Some perceive that EU competition rules will hinder the creation of a European naval shipbuilding 'champion' in spite of national security exemptions, particularly where there is an overlap between commercial and defence activities. The ongoing delay to EU approval of Fincantieri's proposed acquisition of control over France's Chantiers de l'Atlantique – an important facility for the assembly of larger naval vessels – on the basis of its impact on competition with respect to cruise liner construction is a good example. Perhaps more significantly, considerable philosophical differences exist between the largely state-owned shipbuilders in France, Italy and Spain and their privately-held counterparts – such as Germany's ThyssenKrupp Marine Systems (TKMS) and the Dutch Damen – elsewhere in Europe. Some perceive the effective creation of a transnational, state-controlled monolith actually makes it less likely to achieve the efficiency and competitiveness that is required. In the words of Hein van Ameijden, Managing Director of Damen Schelde Naval Shipbuilding (DSNS) consolidation should be '… self-propelled, not politically enforced'.[3]

One example of self-propelled consolidation is taking place in Germany. In January 2020, the government decided to award a consortium of DSNS and Lürssen the contract to build the navy's MKS-180 multi-role combatants over a rival team comprised of German Naval Yards (GNY) and TKMS. The c. €6bn (US$6.8bn) programme is set to dominate the navy's surface warship procurement for the next decade. The decision was quickly protested by GNY. Subsequently however, on 13 May 2020, it was announced that GNY and Lürssen had agreed to merge their naval shipbuilding operations, with Lürssen taking the leading role. In spite of government efforts to promote a three-way deal, TKMS decided not to take part in the merger. This was reportedly in part due to difficulties in aligning the financial interests of its publicly-quoted owner with those of the other two family-owned groups. The absence of TKMS's combat management and submarine expertise from the new venture is undoubtedly a significant loss. Nevertheless, Lürssen's rise from a niche position in German naval shipbuilding to assuming effective control of its entire surface warship building capacity is a remarkable development in marked contrast with more pedestrian efforts to achieve consolidation elsewhere.[4]

A computer-generated image of the Damen proposal for the German Navy's next generation MKS-180 multi-role combat ship, a 9,000-ton leviathan that will be the country's largest surface combatant since the end of the Second World War. In January 2020, Germany announced that Damen – working in partnership with the country's Lürssen shipbuilding group – was the successful bidder for the contract to build four of the vessels, triggering a round of consolidation within the country's naval sector.

TABLE 2.4.1: FLEET STRENGTHS IN WESTERN EUROPE – LARGER NAVIES (MID 2020)

COUNTRY	FRANCE	GERMANY	GREECE	ITALY	NETHERLANDS	SPAIN	TURKEY	UK
Aircraft Carrier (CVN/CV)	1	–	–	1	–	–	–	2
Support/Helicopter Carrier (CVS/CVH)	–	–	–	1	–	–	–	–
Strategic Missile Submarine (SSBN)	4	–	–	–	–	–	–	4
Attack Submarine (SSN)	5	–	–	–	–	–	–	7
Patrol Submarine (SSK)	–	6	11[2]	8	4	2	12	–
Fleet Escort (DDG/FFG)	15	10	13	16	6	11	16	19
Patrol Escort/Corvette (FFG/FSG/FS)	13	5	–	–	–	–	10	–
Missile Armed Attack Craft (PGG/PTG)	–	–	18	–	–	–	19	–
Mine Countermeasures Vessel (MCMV)	13	10[1]	4	10	6	6	11	13
Major Amphibious (LHD/LPD/LPH/LSD)	3	–	–	3	2[3]	3	–	5

Notes:

1 Two further units used as support vessels.

2 Headline figures overstate the actual position, as old ships will be withdrawn once new units are fully operational.

3 Also one joint support ship with amphibious capabilities.

On 12 July 2019, the first French 'Barracuda' type submarine, *Suffren*, was unveiled at a high-profile ceremony at Cherbourg. In spite of the COVID-19 pandemic, she subsequently commenced sea trials late in April 2020. *(Naval Group)*

MAJOR REGIONAL POWERS – FRANCE

France's *Marine Nationale* has had a mixed twelve months. The COVID-19 outbreak aboard the carrier *Charles de Gaulle* – discussed in greater detail in Chapter 4.1 – demonstrated the vulnerability of crowded berthing on older warships and had a significant but short-lived impact on fleet operations. By contrast, the LHD-like *Mistral* class amphibious assault ships have proved their flexibility during the crisis. The test launch of a M51.2 submarine-launched ballistic missile from *Le Téméraire* on 12 June 2020 validated the successful implementation of her previous long refit and provided a tangible demonstration that the pandemic had not impacted the French deterrent's effectiveness. Modernisation of the flotilla of nuclear-powered attack submarines had both ups and downs, whilst a number of important future procurement programmes moved closer to implementation. These are described in further detail below.

Aircraft Carriers: The most important naval decision currently facing the French government is the eventual replacement of *Charles de Gaulle*. This is scheduled to take place around the end of the 2030s, when the carrier will be reaching her fortieth birthday. An 18-month assessment phase to determine the conceptual design of the *porte avion nouvelle generation* (PANG) was launched in October 2018 and its conclusions are reportedly currently with President Macron for a decision. Recent government statements suggest there is little doubt that the project will proceed. However, important questions that remain unanswered include whether nuclear or conventional propulsion will be used and whether a second carrier will be procured to ensure a continuous carrier capability. Irrespective of these decisions, it appears the new design will be built to a conventional catapult assisted take-off but arrested recovery (CATOBAR) configuration using US Navy EMALS and AAG. Construction will take place at Chantiers de l'Atlantique at Saint-Nazaire, the only remaining French yard with the facilities and workforce able to implement the project.

Submarines: On 12 July 2019, President Macron presided over the unveiling of *Suffren*, the first of six 'Barracuda' type nuclear-powered attack submarines, at Naval Group's Cherbourg shipyard. The submarine's nuclear reactor was started for the

first time in December of that year and the boat subsequently commenced sea trials largely on schedule towards the end of April 2020. In light of the current pandemic, trials protocols were adapted to combat the risk of infection, for example by reducing the number of crew on board. Current plans envisage all six of the 5,300-ton submarines entering service by 2030, replacing the existing *Rubis* class on a one-for-one basis. With a design life of around 35 years, the submarines are likely to serve France well into the 2060s.

In spite of its undoubted technological achievement, the 'Barracuda' programme has taken longer than expected to implement. This has placed increased pressure on the *Rubis* class submarines, which have been in service far longer than anticipated. *Saphir* became the first of the class to be withdrawn from service when she decommissioned in July 2019 and is due to be followed by *Rubis* herself – now 37 years old – before the end of 2020. However, a major upset occurred during the morning of 12 June 2020 when a serious fire broke out on *Perle* – the youngest of the class, commissioned in 1993 – whilst she was undergoing a final refuelling and modernisation at Toulon. Although it was fortunate no weapons nor nuclear fuel were on board at the time, her forward 'C' and 'D' sections were severely damaged by a conflagration that was not brought under control until well into the evening. There are fears that her hull may be irreparably damaged. If so, the navy faces an ongoing shortfall in its submarine flotilla for the rest of the decade given both that she is scheduled to be the last of the class to remain in service and also that the lives of the older boats may not be amenable to further extension.

The penultimate French FASM-70 anti-submarine frigate, *La Motte-Picquet*, returned to her home base of Brest in April 2020 to prepare for formal decommissioning later in the year. This picture shows her departing Portsmouth Harbour in the United Kingdom in the August of the previous year. *(Conrad Waters)*

Surface Combatants: The surface flotilla took delivery of its sixth FREMM multi-mission frigate, *Normandie*, on 16 July 2019. She subsequently entered active service at the start of June 2020. Completion of the two final, air-defence configured members of the class – *Alsace* and *Lorraine* – continues at Lorient. However, it is as yet uncertain whether their planned deliveries in, respectively, the first half of 2021 and 2022 will be impacted by the pandemic. Work is also underway on *Amiral-Ronarc'h* – the first of the new smaller *frégates de défense et d'intervention* – which was laid down on 24 October 2019. On the other side of the coin, the penultimate FASM-70 frigate *La Motte-Picquet* returned to Brest for the final time in April 2020 and will be formally decommissioned in September.

Patrol Vessels and Auxiliaries: After several years of delay, the programme to replace France's numerous offshore patrol vessels is now picking up pace. Having previously pursued a unified solution, this project has now been split into three discrete parts. Three 700-ton *La Confiance* class patrol vessels specifically designed to operate in Guyana and the Antilles have already been completed by Boulogne-headquartered Socarenam. In a pre-Christmas gift, the company was notified on 24 December 2019 that it would also be allocated the contract to build six larger *patrouilleurs outre-mer* (POM). The 1,300-ton vessels will have a length of 80m, a maximum speed of 24 knots and a lengthy range of up to 5,500 miles. Armament includes a 20mm-armed remote weapons station whilst there is a flight deck suitable for drone operation. The vessels will serve in pairs in the French overseas territories of French Polynesia, New Caledonia and Réunion. All will be in service by 2025.

The third part of the programme is for ten larger and more sophisticated vessels termed *patrouilleurs océaniques* that will be located in the French Metropolitan bases of Brest, Cherbourg and Toulon. They will replace the remaining A-69 *avisos* re-rolled as patrol ships and the basic OPV-54 patrol vessels that currently operate from Cherbourg. The official go-ahead for the programme was given on 25 June 2020. However, little is known about the characteristics required for the new vessels beyond reports that they will be equipped with sonar to help safeguard the submarine force. It is also not entirely certain how this project will interface with France's involvement in the EPC programme mentioned in the introduction. France's reported requirement for between nine and eleven EPCs is more than required to replace the existing *Floréal* class. It is therefore possible that part of the oceanic patrol vessel requirement might be met by the EPC initiative.

Meanwhile construction started on 18 May 2020 on *Jacques Chevallier*, the first of four AOR-type logistic support ships based on the Italian Navy's *Vulcano* design. Scheduled for delivery between

TABLE 2.4.2: FRENCH NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CVN	**CHARLES DE GAULLE**	1	42,000 tons	262m x 33/64m x 9m	Nuclear, 27 knots	1,950	2001
Principal Surface Escorts							
Frigate – FFG	**AQUITAINE** (FREMM)	6	6,000 tons	142m x 20m x 5m	CODLOG, 27 knots	110	2012
Frigate – FFG	**FORBIN** ('Horizon')	2	7,100 tons	153m x 20m x 5m	CODOG, 29+ knots	195	2008
Frigate – FFG	**CASSARD** (FAA-70)	1	5,000 tons	139m x 15m x 5m	CODAD, 30 knots	250	1988
Frigate – FFG	**GEORGES LEYGUES** (FASM-70)	1	4,800 tons	139m x 15m x 5m	CODOG, 30 knots	240	1979
Frigate – FFG	**LA FAYETTE**	5	3,600 tons	125m x 15m x 5m	CODAD, 25 knots	150	1996
Frigate – FSG	**FLORÉAL**	6	3,000 tons	94m x 14m x 4m	CODAD, 20 knots	90	1992
Frigate – FS[1]	**D'ESTIENNE D'ORVES** (A-69)	7[1]	1,300 tons	80m x 10m x 3m	Diesel, 24 knots	90	1976
Submarines							
Submarine – SSBN	**LE TRIOMPHANT**	4	14,400 tons	138m x 13m x 11m	Nuclear, 25 knots	110	1997
Submarine – SSN	**RUBIS**	5	2,700 tons	74m x 8m x 6m	Nuclear, 25+ knots	70	1983
Major Amphibious Units							
Amph Assault Ship – LHD	**MISTRAL**	3	21,500 tons	199m x 32m x 6m	Diesel-electric, 19 knots	160	2006

Note:
1 Now officially reclassified as offshore patrol vessels. One scheduled to be withdrawn shortly.

A recent graphic of the new French LSS logistic support ship, which is based on Italy's *Vulcano*. Four of the class will be assembled at the Chantiers de l'Atlantique shipyard in Saint-Nazaire with the involvement of Fincantieri and Naval Group. *(OCCAR)*

2022 and 2029, the ships are being assembled at Chantiers de l'Atlantique from sections fabricated both on site and at Fincantieri's facility at Castellammare di Stabia, near Naples. The 31,000-ton ships will be 194m in length and have a cargo capacity of 13,000 metric tonnes.

Table 2.4.2 provides further details of fleet composition as of mid-2020.

MAJOR REGIONAL POWERS – ITALY

The Italian Navy's major units are currently summarised in Table 2.4.3. The last twelve months have seen formal decommissioning ceremonies held for the frigates *Aviere*, *Euro* and *Scirocco* as well as the last two *Minerva* class corvettes *Chimera a*nd *Driade.* All had already left the operational fleet for some time. Also departing the navy were the training vessels *Astice*, *Murena* and *Porpora.* Originally delivered as coastal minesweepers between 1957 and 1958, they were a variant of the British 'Ham' class design and may well have been the last of the type in naval service anywhere in the world when they lowered their flags for the final time on 5 December 2019.

The navy has not welcomed any significant new arrivals to the fleet in the past year, partly because of the impact of the COVID-19 pandemic on ship-yard work. However, two new UNPAV (*unità navale polifunzionale ad altissima velocità*) high

speed interceptors – *Angelo Cabrini* and *Tullio Tedeschi* – designed to operate with the navy's Special Forces were commissioned in July 2019 and March 2020.[5]

As mentioned in last year's *Seaforth World Naval Review*, the *Marina Militare* set out its strategic plan for the 15-year period up to 2034 in mid-2019.[6] This envisages a modernised and expanded fleet built around the carrier *Cavour*, the amphibious assault ship *Trieste* and three other new amphibious ships, eight submarines, four destroyers, ten FREMM frigates, seven new PPA ocean patrol vessels and eight of the proposed EPCs, as well as minor vessels and supporting ships. *Trieste* and the PPAs are already being delivered under the auspices of the 'Naval Law' of 2014/15 but a major programme of new construction will be needed to realise the navy's ambitions. It remains uncertain whether the money is available to pay for it.

The last year has, however, seen good progress achieved with existing programmes, coronavirus notwithstanding. The ninth FREMM multi-mission frigate *Spartaco Schergat* is almost ready for delivery from Fincantieri's Muggiano yard near La Spezia whilst the tenth and final ship, *Emilio Bianchi*, was named at the company's Riva Trigoso facility on 25 January 2020.[7] But there is some uncertainty as to whether these two ships will enter Italian service as they reportedly form part of the large arms sale Italy is currently negotiating with Egypt. The integrated Riva Trigoso-Muggiano complex is also making headway with the follow-on contract, one of a number placed under the Naval Law, for the frigate-like PPA (*Pattugliatore Polivalente d'Altura*) multi-purpose offshore patrol ship design. The lead ship – *Paolo Thaon di Revel* – commenced preliminary sea

The lead Italian frigate-like PPA *Paolo Thaon di Revel* pictured on preliminary sea trials in the Gulf of La Spezia on 12 November 2019. The first of at least seven vessels being built in different armament configurations, she is due to join the *Marina Militare* in May 2021. *(OCCAR)*

Table 2.4.3: ITALIAN NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CV	**CAVOUR**	1	27,100 tons	244m x 30/39m x 9m	COGAG, 29 knots	800	2008
Aircraft Carrier – CVS	**GIUSEPPE GARIBALDI**[1]	1	13,900 tons	180m x 23/31m x 7m	COGAG, 30 knots	825	1985
Principal Surface Escorts							
Frigate – FFG	**CARLO BERGAMINI** (FREMM)[2]	8	6,700 tons	144m x 20m x 5m	CODLOG, 27 knots	145	2013
Frigate – FFG	**ANDREA DORIA** ('Horizon')	2	7,100 tons	153m x 20m x 5m	CODOG, 29+ knots	190	2007
Destroyer – DDG	**DE LA PENNE**	2	5,400 tons	148m x 16m x 5m	CODOG, 31 knots	375	1993
Frigate – FFG	**MAESTRALE**	4	3,100 tons	123m x 13m x 4m	CODOG, 30+ knots	225	1982
Submarines							
Submarine – SSK	**TODARO** (Type 212A)	4	1,800 tons	56m x 7m x 6m	AIP, 20+ knots	30	2006
Submarine – SSK	**PELOSI**	4	1,700 tons	64m x 7m x 6m	Diesel-electric, 20 knots	50	1988
Major Amphibious Units							
Landing Platform Dock – LPD	**SAN GIORGIO**	3	8,000 tons	133m x 21m x 5m	Diesel, 20 knots	165	1987

Note:
1 Now operates largely as a LPH.
2 Class includes BERGAMINI (GP) and FASAN (ASW) variants.

trials in November 2019 and a sister – *Francesco Morosini* – was named at a low-key ceremony on 22 May 2020. Three of the other five ships subject to firm orders are also under construction. Options exist for a further three members of the class but current plans appear to be to transition production to the new EPC once the contractually-committed ships have been built.

The other two major units ordered under the Naval Law are the logistic support ship *Vulcano* and the amphibious assault ship *Trieste. Vulcano* was originally scheduled for delivery in September 2019 but a fire whilst the ship was fitting out has delayed this date by around a year. She finally commenced sea trials early in December 2019. Completion of the more complex *Trieste* is not expected before 2022 but she has already been to sea. Assembled at the Castellammare di Stabia facility, she was transferred to Muggiano early in January 2020, where final outfitting and combat installation work will be completed. Although primarily designed for the amphibious role, *Trieste* will also act as a back-up to the carrier *Cavour* and has been equipped with a ski-jump to support F-35B strike fighter operations. *Cavour* has been undertaking modifications to operate the F-35B over the past year, entering the 'Edgardo Ferrati' basin at Taranto in July 2019 for the application of thermal-resistant coatings to her flight deck and a range of other improvements. The work was completed in May 2020, with the carrier scheduled to deploy to the United States in the summer to undertake F-35B operating trials similar to those performed by the British Royal Navy's *Queen Elizabeth.*

Work continues on developing the Italian Navy's next-generation Type 212A NFS 'near future submarine' programme. Four units are planned to replace the remaining *Sauro* class boats on a one-for-one basis. Italian media reports suggest funding for the entire project has now been secured, allowing work to commence shortly. The Italian boats will continue a trend of divergence already apparent from the original common German-Italian programme, exhibiting considerable differences from the Type 212-CD variant destined for the German and Norwegian fleets.

Italy's aircraft carrier *Cavour* has been undertaking a refit at Taranto to prepare for initial trials with the F-35B strike fighter. This picture shows her exiting the Edgardo Ferrati basin in Taranto in November 2019 whilst the relevant work was underway. *(Italian Navy)*

MAJOR REGIONAL POWERS – SPAIN

There has been limited news with respect to Spanish naval procurement over the past year following the signing of the major new contract for five F-110 type frigates in April 2019, which will be reportedly known as the *Bonifaz* class. It now appears that Navantia will not be in a position to start construction of the new vessels at its Ferrol yard until early 2022. This opens up a break in production after the two *Supply* class replenishment vessels for the Royal Australian Navy have been completed. Suggestions have been made to advance the construction of the planned submarine support and rescue variant of the *Meteoro* patrol vessel design – the so-called BAM-IS – or even a second *Cantabria* class replenishment vessel. If eventually ordered, the current plan is to construct the BAM-IS at Navantia's shipyards in the Bay of Cadiz, which are already busy with work on Saudi Arabia's new corvettes. It would seem likely that the previous ambition to acquire further batches of BAMs will now be overtaken by Spain's involvement in the EPC project.

Increasing confidence surrounds the previously troubled S-80 Plus submarine construction programme. The lead boat – *Isaac Peral* – is on track for launch early in 2021 and should be delivered to the navy during the course of the following year. The final two members of the class will be equipped from build with a bioethanol-based AIP plant supplied by Spanish company Abengoa which will be subsequently retrofitted to the first pair. The *Armada Española* are reportedly already pressing for the construction of an additional batch of submarines to retain the industrial knowledge relearned from the current programme. Meanwhile, the navy decommissioned the existing *Agosta* class submarine *Mistral* on 10 June 2020 after cancelling plans for a further life extension with a reported saving of over €43m (c. US$50m). Whilst reinforcing perceptions that the S-80 Plus programme is now on track, her withdrawal leaves the navy with just two submarines until *Peral* is delivered.

The saving may help pay for repairs to the mine countermeasures vessel *Turia*, which ran aground off the La Manga spit in Murcia on 27 August 2019 whilst searching for the wreckage of a crashed

Table 2.4.4: SPANISH NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Principal Surface Escorts							
Frigate – FFG	**ÁLVARO DE BAZÁN** (F-100)	5	6,300 tons	147m x 19m x 5m	CODOG, 28 knots	200	2002
Frigate – FFG	**SANTA MARIA** (FFG-7)	6	4,100 tons	138m x 14m x 5m	COGAG, 30 knots	225	1986
Submarines							
Submarine – SSK	**GALERNA** (S-70/AGOSTA)	2	1,800 tons	68m x 7m x 6m	Diesel-electric, 21 knots	60	1983
Major Amphibious Units							
Amph Assault Ship – LHD	**JUAN CARLOS I**	1	27,100 tons	231m x 32m x 7m	IEP, 21 knots	245	2010
Landing Platform Dock – LPD	**GALICIA**	2	13,000 tons	160m x 25m x 6m	Diesel, 20 knots	185	1998

The Spanish mine countermeasures vessel *Turia*, a derivative of the British *Sandown* class, was severely damaged in a grounding incident in August 2019. Repairs are estimated to cost in the region of €25m. *(Conrad Waters)*

aircraft. After considering decommissioning the ship, the navy has contracted with Navantia's Cartagena yard to conduct the repairs at an estimated cost of €25m.

Table 2.4.4. provides a summary of major fleet components as of mid-2020.

MAJOR REGIONAL POWERS – UNITED KINGDOM

The British Royal Navy's future direction of travel essentially remains in flux, with the lengthy period of political paralysis induced by the Brexit process almost immediately followed by the demands of the COVID-19 crisis. The new administration led by Boris Johnson has now restarted its Integrated Review of security, defence, development and foreign policy that was suspended during the height of the health crisis but which should still report before the year's end. There are indications of considerable tension between the instincts of government advisers for radical change in security objectives and procurement compared with the more conservative views of the existing defence establishment. The review also takes place against a backdrop of a significant projected shortfall in defence ministry funding that the financial fallout from the pandemic is unlikely to ease.

For the time being, the Royal Navy's top priority has been to re-orientate itself from the recent focus on individual ship deployments towards a return to carrier strike group operations whilst maintaining its ability to perform its myriad of existing tasks during the height of a national emergency. The former task has been progressing well, as acknowledged in a 26 June 2020 report by the United Kingdom's National Audit Office (NAO) on preparations to deploy the new capability by 2021.[8] More negatively, the report pointed out delays to the Crowsnest airborne radar system and fleet solid support (FSS) ships – as well as longer-term problems relating to funding for F-35B jets and logistics support – as hindering the overall vision for carrier-enabled power projection (CEPP).

Future procurement is dominated by submarine programmes, which are currently not running completely to plan. The last year has, however, been broadly positive from a perspective of overall fleet strength, with deliveries of the second aircraft carrier *Prince of Wales* and the fourth *Astute* class nuclear powered attack submarine *Audacious* being the main factors influencing the summary provided in Table 2.4.5. Further details on developments with respect to different warship categories follow.

Aircraft Carriers: The lead *Queen Elizabeth* carrier has spent the last twelve months steadily working towards achieving an initial operating capability for carrier strike, which is targeted for December 2020. A second voyage to the eastern seaboard of the United States in the form of the 'Westlant 19' deployment during the autumn of 2019 saw British-owned F-35B strike fighters operate from the carrier for the first time. *Queen Elizabeth* subsequently conducted initial carrier qualification training and further operational sea training in home waters

Table 2.4.5: BRITISH ROYAL NAVY: PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft Carriers							
Aircraft Carrier – CV	**QUEEN ELIZABETH**	2	65,000 tons	284m x 73m x 11m	IEP, 26 knots+	1,600	2017
Principal Surface Escorts							
Destroyer – DDG	**DARING** (Type 45)	6	7,500 tons	152m x 21m x 5m	IEP, 30 knots	190	2008
Frigate – FFG	**NORFOLK** (Type 23)	13	4,900 tons	133m x 16m x 5m	CODLAG, 30 knots	185	1990
Submarines							
Submarine – SSBN	**VANGUARD**	4	16,000 tons	150m x 13m x 12m	Nuclear, 25+ knots	135	1993
Submarine – SSN	**ASTUTE**	4	7,800 tons	93m x 11m x 10m	Nuclear, 30+ knots	100	2010
Submarine – SSN	**TRAFALGAR**	3	5,200 tons	85m x 10m x 10m	Nuclear, 30+ knots	130	1983
Major Amphibious Units							
Landing Platform Dock – LPD	**ALBION**	2[1]	18,500 tons	176m x 29m x 7m	IEP, 18 knots	325	2003
Landing Ship Dock – LSD (A)	**LARGS BAY**	3	16,200 tons	176m x 26m x 6m	Diesel-electric, 18 knots	60	2006

Notes:
1. One at extended readiness.

before participating in her inaugural exercise, named Crimson Ocean, in June 2020. Meanwhile, sister ship *Prince of Wales* commenced sea trials in September 2019 prior to commissioning on 10 December that year.

Submarines: The long-delayed commissioning of the *Astute* class submarine *Audacious* took place at BAE Systems' yard in Barrow on Furness in the midst of pandemic lockdown on 3 April 2020. The new vessel subsequently arrived at her operating base at Faslane four days later. However, it will be some months until she becomes fully operational. Her delivery had been progressively delayed by a significant 'technical issue' that emerged after launch and which is rumoured to have required the use of equipment from a boat later in the build cycle to make good. Although the Ministry of Defence has remained notably tight-lipped about the whole issue, it has been confirmed that there has been a knock-on delay to the fifth boat – *Anson* – and that further schedule challenges exist with the remaining build.

The problems with *Audacious* will be particularly concerning for the Royal Navy given the potential impact on the following programme for *Dreadnought* class submarines, which are of huge strategic importance. In January 2020, the NAO reported significant cost overruns and delays relating to a number of infrastructure projects supporting the submarine-based nuclear deterrent, including a new primary build facility at Barrow.[9] A major refit and refuelling of the current generation strategic submarine, *Vanguard*, has also fallen badly behind schedule at the Devonport complex, adding to the sense that all is not well with Britain's nuclear submarine programmes.

The long-delayed *Audacious*, the fourth *Astute* class nuclear-powered attack submarine, seen arriving at her home base at Faslane for the first time on 7 April 2020. A degree of marine growth appears to have formed along her waterline in the three years since she was launched in April 2017. *(Crown Copyright 2020)*

Surface Combatants: In September 2019 it was announced that Babcock's 'Arrowhead 140' had been selected over BAE Systems' competing 'Leander' design and a MEKO 200-based proposal from TKMS for the Type 31 general-purpose frigate programme. Whilst the contract for five vessels subsequently signed in November was in line with the £1.25bn (US$1.6bn) budget initially set for the project, expenses involved with the supply of government-furnished equipment and other overheads will push total programme cost to an estimated £2bn (US$2.5m). There has also been considerable slippage in the overly-optimistic schedule that was initially set for deliveries. The first ship is due to enter operational service in 2027 rather than the improbable 2023 target that was the original aim. This may require a few more years of service to be squeezed out of the older Type 23 frigates that the new ships are meant to replace. In spite of these problems, the successful conclusion of a contract reflects progress with achieving the ambitions of the British National Shipbuilding Strategy established in 2017. In the words of Sir John Parker – the industrialist instrumental in establishing the original strategy's principles – when reviewing its implementation, the contract has '… demonstrated the principles behind the Strategy and shown that grip on content specification, design, and pace of timescale in contracting has been established'.[10]

The Babcock design is based on the Royal Danish Navy's *Iver Huitfeldt* class. Whilst planned armament based around a 57mm gun and a small cluster of Sea Ceptor surface-to-air missiles is light, the c. 6,000-ton hull has plenty of margin for subsequent growth. Key sensors and combat management systems are being provided by programme partner Thales, thereby requiring a new supply chain from the BAE Systems-supplied sensors and systems typically found in other Royal Navy combatants.

Meanwhile, construction continues at BAE Systems' Govan yard on *Glasgow*, the first of the eight more complex Type 26 anti-submarine frigates (also referred to as Global Combat Ships) that will replace the remainder of the Type 23s. Launch is expected to take place by the end of 2021 but delivery to the Royal Navy is not scheduled before 2025. Work on *Cardiff* – second of the three vessels formally ordered to date – commenced on 14 August 2019.

Patrol Vessels and Auxiliaries: The last year has seen further strengthening of the Royal Navy's patrol

The Royal Navy's new Batch II 'River' class offshore patrol vessels *Trent* and *Tamar* have both been delivered over the course of the past 12 months. *(Derek Fox/Conrad Waters)*

vessel fleet as additional Batch II 'River' class vessels enter service. Four of the five have now been delivered, with *Forth* forward deployed to the Falkland Islands and *Medway* to the Caribbean. It appears that the current intention is also to use the remainder of the Batch II vessels for overseas deployments, leaving the older Batch I 'Rivers' to undertake fishery protection and other assignments in home waters. All three ships of the class are now fully operational after *Severn* concluded her post-reactivation training towards the end of June 2020. Conversely, the sole leased Modified Batch I 'River' *Clyde* was withdrawn from service upon her replacement by *Forth* in the Falkland Islands' guard ship role and has now been returned to owner BAE Systems.[11]

A dedication ceremony for the fleet tanker *Tideforce* on 30 July 2019 essentially marked the final realisation of the four-ship 'Tide' class programme. The international competition for the follow-on programme for two or three FSS support ships was halted in November 2019, possibly because of growing pressure to undertake the contract in the United Kingdom. It is anticipated the programme will be relaunched in the second half of 2020. A 'Team UK' consortium encompassing Babcock, BAE Systems, Cammell Laird and Rolls-Royce is likely to face off against an alliance of Navantia, Harland & Wolff and BMT for the contract award.

MID-SIZED REGIONAL FLEETS

Germany: The *Deutsche Marine*'s fortunes are starting to turn around after a period of steady decline throughout the post-Cold War period as defence spending increases. Notably, the selection of the consortium to build the new MKS-180 multi-role combat ships already referenced in the introduction has been followed, first, by parliamentary approval for the programme and, subsequently, by a contract with Damen for an initial four ships. Overall programme cost – including some support facilities – is estimated at €6bn, of which €4.6bn (US$5.2bn) is the actual value of the shipbuilding contract. Delivery of the four ships is targeted for 2027–31, with options included for two additional ships to be delivered after 2032. With a waterline length of 155m and a displacement of c. 9,000 tons, the new vessels will be the largest surface combatants in Europe and the most powerful in German Navy service since the end of the Second World War. A key feature of the design is a significant element of modularity, with options for a number of different modules to be shipped according to mission in a broadly similar fashion to the US Navy's Littoral Combat Ships.

Pending realisation of the MKS-180, the navy will benefit from deliveries of the remaining members of the F125 *Baden-Württemberg* class stabilisation frigates and the second batch of K130 *Braunschweig* class corvettes. The second, much-delayed F125 type frigate, *Nordrhein-Westfalen*, was commissioned in June 2020. The two remaining vessels will be in service before the end of 2021. The five K130s are expected to follow from 2022 onwards with the second – named *Emden* – laid down on 30 January 2020. With *Lübeck* the only remaining member of the F122 class still awaiting withdrawal following the decommissioning of *Augsburg* in December 2019, it can be seen that surface ship numbers are set to grow steadily throughout the remainder of the decade.

Although the German Ministry of Defence has confirmed plans to build further Type 212 submarines to the new 'CD' standard as part of a larger programme with Norway, a firm contract has yet to be announced. Other pending awards are contracts for two new c. 20,000-ton Type 707 fleet replenishment oilers to replace the existing *Röhn* and *Spessart* in the mid-2020s and for a second batch of NH90 'Sea Lion' helicopters in substitution for the existing Sea Lynx. In June 2020, the navy announced the official hand over of the first of eighteen of the type that have already been contracted as replacements for the force's veteran Sea Kings.

The German frigate *Lübeck* is the last of eight F122 class frigates remaining in service. She is due to be decommissioned over the next 12 months as the remaining replacement F125 *Baden-Württemberg* class stabilisation frigates enter service. *(Conrad Waters)*

Greece: The Hellenic Navy will clearly be watching the deteriorating political environment in the Eastern Mediterranean with some concern given the legacy of the Eurozone's previous crisis on fleet investment. Although large numbers of vessels remain on the fleet's roster in the seeming absence of a formal decommissioning programme of older ships, many will be of dubious operational value. Indications of increasing collaboration with both Egyptian and Italian naval forces suggest significant efforts to bolster regional partnerships form part of the response to this difficult situation.

News with respect to more tangible efforts to strengthen the fleet remains limited given that economic fundamentals remain far from positive. The last year has seen financial approval to embark on a range of modest enhancements, including acquisition of a small number of MH-60R helicopters and modernisation of the MEKO 200HN *Hydra* class frigates. The long-awaited arrival of the two final *Roussen* fast attack craft is also imminent, with the sixth vessel *Ypoploiarchos Karathanasis* now scheduled for delivery in July 2020. More ambitious procurement objectives include acquisition of a pair of French FDI frigates. Although a letter of intent relating to these was signed in October 2019, this has yet to be followed by a firm contract. The country has also been an early signatory to the European EPC programme. A more interesting development has been the donation of two support vessels – *Atlas I* and *Hercules* – by Greek shipping magnate Panos Laskaridis, possibly influenced by former defence minister Panos Kammenos's widely reported pleas asking wealthy Greeks to fund new warships.

Belgium and the Netherlands have agreed to acquire two pairs of new frigates in a programme being led by the Dutch Ministry of Defence. In June 2020 the project's conceptual design phase was completed, leading to the c. 5,500-ton ship illustrated in this graphic. *(Dutch Ministry of Defence)*

The Netherlands and Belgium: The closely associated Royal Netherlands Navy and Belgian Naval Component continue to make progress with their collaborative procurement programmes. These encompass acquisitions of six new mine countermeasures vessels and two frigates for each navy. The project for the mine warfare vessels is under Belgian leadership and saw the Belgium Naval Robotics Consortium awarded a contract to undertake the programme in May 2019. Attention has subsequently turned to the frigate acquisition, which is being led by the Netherlands. In June 2020 it was announced that the conceptual design (research) phase had been successfully completed, allowing the key parameters of the new ships to be determined. A series of trade-offs has meant that the ships will be smaller and cheaper than originally envisaged, partly by adopting a modular concept under which not all the ships' designated tasks will be able to be performed during the same mission. Nevertheless, with a planned displacement of c. 5,500 tons, the new ships will be substantially larger than the 'M' class frigates they are scheduled to replace. Award of a detailed design and construction contract is anticipated before the end of 2021. However, it will not be until 2027 – two years later than initially envisaged – before the first vessel is delivered.

Two other programmes that are being pursued by the Netherlands on a purely national basis made mixed headway during the last year. On 13 December 2019, it was announced that design proposals from Naval Group, Saab and TKMS had been shortlisted for further consideration in the

In February 2020, the Netherlands signed a contract with local company Damen for a new combat support ship, which will be named *Den Helder*. This graphic suggests a considerable amount of attention has been focused on ensuring the new design's radar stealth. *(Damen)*

competition to build the country's next submarine, effectively further delaying an already protracted process. Current plans envisage award of a c. €2.5bn (US$2.8bn) contract in the course of 2022. Four submarines will be delivered to replace the existing four *Walrus* class boats by 2031 in a programme that will include substantial Dutch industrial participation. Subsequently, in February 2020, a contract was signed with Damen for the construction of the new replenishment vessel *Den Helder*. The new 200m-long combat support ship will be delivered in mid-2024 under a programme budgeted to cost €375m (US$425m).[12]

Turkey: As mentioned in the introduction to Chapter 2.3, Turkey's Erdoğan presidency is becoming increasingly assertive in its pursuit of political and economic influence in the Eastern Mediterranean, driving something of a regional arms race. The Turkish Navy clearly has an important role to play in supporting the government's objectives, with ongoing investment in developing its capabilities into one of the most proficient in the regime now starting to pay dividends. The last year has seen further progress.

The most significant recent development has been the launch ceremony for the first Turkish Type 214 AIP-equipped submarine *Piri Reis*, which took place at the Gölcük Naval Shipyard on 22 December 2019. The event's importance was marked by the attendance of President Erdoğan as guest of honour. The badly delayed programme for six of the German TKMS-designed submarines now seems to be getting into its stride, with steel for the fifth boat cut on the same day. Reports suggest that completion of the programme will be followed by a project for a truly national 'MILDEN' submarine, replicating the steady process of indigenisation that is already evident in the surface fleet.

That process took a further step forward on 29 September 2019 with commissioning of *Kınalıada*, the final member of the four-strong 'Ada' class variant of the 'MILGEM' national surface ship programme. Construction is already well underway on *Istanbul*, the first of the evolved and enlarged 'I' class vessels which will probably be launched within the course of the next year. Four of these vessels are also planned. The 'Ada' class hull is also being used as the basis for the intelligence-gathering ship *Ufuk*, currently being outfitted at Istanbul Naval Shipyard. Meanwhile further evidence of indigenisation is evident in the increasing use of locally-developed technology in modernising existing vessels, notably in the planned modernisation of the MEKO 200TN Batch 2 *Barbaros* class frigates by the Aselsan-Havelsan consortium.

Assembly of the amphibious assault ship *Anadolu* at Sedef Shipbuilding is apparently proceeding ahead of schedule in spite of a fire aboard in April 2019. Some reports suggest that the carrier-like ship – a derivative of the Spanish *Juan Carlos I* design – will commence trials during the second half of 2020. There have also been suggestions of ambitions for a second vessel – to be named *Trakya* – but it is doubtful whether the political or economic support exists to make these a reality. In any event, the design's utility in Turkish service has been significantly reduced by the country's expulsion from the F-35 programme as the 'B' STOVL variant of the aircraft is the only fast jet currently in production that can operate from its flight deck.

A lower-key – but arguably equally important – project is the construction of a new replenishment vessel at Sefine Shipyard. More details of the ship emerged in mid-2020 when GE Marine announced it had been awarded a contract to provide two LM-2500 gas turbines for the ship. The choice is an unusual one, suggesting a desire for speed over economy found only in a handful of high end US Navy and PLAN combat support ships.[13]

OTHER REGIONAL FLEETS

Black Sea and Mediterranean: In September 2019, Russia returned the two Project 58155 'Gyurza M' armoured gunboats and the tug *Yany Kapu* that has been seized from **Ukraine** in the course of the Kerch Strait incident the previous year. With their crews already back in Ukraine's hands following a prisoner exchange in September of that year, something of a line has been drawn under that particular incident, if not the wider Russo-Ukrainian conflict. Meanwhile, the Ukrainian Navy is continuing a cash-constrained process of rebuilding based on its 2019 naval strategy that initially seeks to expand domain awareness and then sea denial capacity in its coastal zone. In June 2020, the United States approved the sale of sixteen Mark VI fast patrol boats to the country at a reported cost of US$600m. The c. 72-ton vessels will supplement the locally-

The fourth and final 'Ada' class corvette *Kinaliada* pictured off Istanbul in November 2019. Production has now transitioned to the larger 'I' or *Istanbul* class as Turkey continues to indigenise its naval requirements. *(Devrim Yaylali)*

built Project 51855 gunboats in forming the basis of a 'mosquito fleet' to achieve this aim. The move follows the transfer of two larger but older former US Coast Guard 'Island' class cutters. The new *Sloviansk* and *Starobilsk* arrived in Odessa as deck cargo in October 2019, formally entering service the following month.

Elsewhere in the Black Sea, both **Romania** and **Bulgaria** have made decisions on new surface warship procurement in the last year. In early July 2019, Romania announced it had selected France's Naval Group – in partnership with local builder Santierul Naval Constanta – to build four 'Gowind' type corvettes as part of a package that also includes modernisation of the two existing Type 22 frigates. Naval Group's proposal was selected over competing bids from Damen and Fincantieri in spite of the strong performance of Damen's Galati yard in securing a considerable volume of naval work. Later, in February 2020, Fincantieri lost a second competition in the region when Bulgaria announced it had selected Germany's Lürssen to build two modular multi-mission patrol vessels. Local firm MTG Dolphin had also been a contender for the contract but withdrew at a late stage, reportedly to become Lürssen's local partner in the programme. The winning design is believed to be an upgraded variant of the German company's OPV80/85/90 series that has already been selected by Brunei and Australia.

Turning to the Mediterranean, the refugee emergency of recent years has been largely eclipsed by wider concerns but still continues, albeit at a lower level. **Malta** – one of the countries in the European Union's front line – has been provided additional assistance to help deal with the crisis. It awaits delivery of its subsidized flagship offshore patrol vessel from Italy's Cantiere Navale Vittoria. By contrast, the Adriatic has now largely escaped the conflicts of the past and naval investment is at a relatively low level. In an exception to this general trend, **Croatia** has decided to order a four of its indigenously-built *Omiš* class from the Brodosplit yard after taking delivery of the prototype vessel at the end of 2018. Armed with a Turkish Aselsan 30mm remote weapons system, the c. 200-ton vessels will replace the former Yugoslavian Navy 'Mirna' class patrol boats now in Croatian service.

The Atlantic and Northern Europe: In the Atlantic, **Ireland's** naval service continues to suffer a crewing crisis which has taken serving personnel numbers below 900 and may soon see a third vessel from its small fleet confined to harbour. **Portugal's** navy is another struggling to fill its billets but otherwise faces a largely positive environment under the provisions of an updated Military Programming Law covering the period 2019–2030 that took effect in June 2019. The document earmarks funding for three significant new naval acquisition projects – six offshore patrol vessels, a new fleet replenishment ship and a multi-purpose logistics vessel. All are likely to be built at the resurrected West Sea Viana Shipyard at Viana do Castelo. Procurement of the offshore patrol ships is the highest priority given the need to replace the re-rolled Cold War-era corvettes that had previously been undertaking this task but which have now largely been withdrawn. The programming law also provides funding for limited mid-life modernisations of the three MEKO 200PN *Vasco da Gama* class frigates, supplementing the rather more extensive upgrades to the two former Royal Netherlands Navy *Bartolomeu Dias* frigates being undertaken at Den Helder.

In Scandinavia, **Norway** released a new long-term defence plan in April 2020.[14] Although providing an overall increase in funding, there was disappointment that government chose the lowest-cost option presented by the Norwegian Armed Forces. From a naval perspective, the plan maintains support for replacing the existing six *Ula* class submarines around 2030 with four boats of the Type 212CD design in a joint programme being undertaken by Germany. However, there will be no immediate replacement for the frigate *Helge Ingstad* that was written off following a collision in 2018. Instead the frigate force will remain at just four ships pending decisions on the type and number of a new class of surface vessel in the last planning period. An interim report issued by Norway's Accident Investigation Board in November 2019 heavily criticised navy personnel's training, experience and bridge watch procedures as being key factors behind the collision.[15]

In September 2019, **Finland** signed a series of contracts covering the acquisition of four new multi-role *Pohjanmaa* class corvettes under the Squadron 2020 programme. The c. 3,900-ton, 114m long ships will be considerably larger than existing Finnish Navy combatants and greatly increase the fleet's operational capabilities. Building has been entrusted to Rauma Marine Constructions, which will commence work on the first vessel in 2022. The overall cost of the programme now amounts to c. €1.3bn (US$1.5bn), around €100m more than previously estimated. Meanwhile mid-life modernisation work continues on the four *Hamina* class fast attack craft that will supplement the new corvettes in the operational fleet's front line. *Tornio*, first of the class to be upgraded, was returned to the fleet at the start of 2020. Operationally, the Finnish Navy continues to work closely with that of neighbouring **Sweden**, whose fleet is discussed in more detail in Chapter 2.4A.

Although **Denmark's** naval industry has recently gained further success with the sale of its *Iver Huitfeldt* class design to the British Royal Navy – and with a possible further sale to Indonesia pending – no significant domestic shipbuilding programmes are currently underway. At the other end of the Baltic, **Lithuania** announced the acquisition of the former British Royal Navy 'Hunt' class mine countermeasures vessel *Quorn* in April 2020. After modernisation, she will join two other members of the class already in Lithuanian service. **Estonia** has also been modernising its minehunting assets through a c. €30m (US$34m) upgrade of its existing *Sandown* class vessels performed at Babcock's facility at Rosyth.

On 28 November 2019, **Poland** commissioned the MEKO 100 corvette-like offshore patrol vessel *Slazak* into naval service, completing an odyssey that had begun when the vessel's keel was laid exactly 18 years previously. She is the second new vessel to join the Polish Navy in recent years, following on from the prototype Project 258 'Kormoran II' class minehunter *Kormoran* delivered in November 2017. Two further members of this latter class are under construction following first steel cutting for the third, *Mewa*, in mid-2019. It also seems that orders for a second batch of three ships of the type are planned in due course. The Polish Navy has ambitions for a wide range of additional procurement, notably renewal of the submarine force. Local news reports suggest there are ongoing discussions to lease at least one of the Swedish modified A17 *Södermanland* class submarines as an interim measure until the long-delayed purchase of a new class can be finalised.

RUSSIA

The Russian Navy continued to demonstrate its ongoing recovery from previous post-Cold War neglect over the past year. From a symbolic perspective, perhaps the most noteworthy event was the

completion of a global circumnavigation by the Project 22350 frigate *Admiral Gorshkov* in August 2019, putting the fleet well and truly back on the map.[16] The final stage of the voyage saw the frigate participate in the Ocean Shield 2019 exercise in the Baltic. Involving around seventy ships and sixty aircraft, the series of drills was reportedly Russia's largest such exercise for over 30 years, practising a number of possible scenarios that might involve combat with NATO forces in the region. The navy has also remained particularly active in the Mediterranean, where its role in providing logistics support for the Assad regime in Syria's civil war has already proved decisive. In December 2019, it was reported that Russia plans massive commercial investment developing port facilities at Tartus in northern Syria, further strengthening its influence over the hub for its naval forces in the region.[17]

From a structural perspective, the navy has maintained its focus on underwater and littoral forces over larger surface warships. Given both financial and technological constraints this seems a sensible approach that has prioritised resources on those naval assets that are most important to overall Russian strategic aims. However, the strategy means that flag-waving initiatives such as the *Gorshkov* voyage will be more the exception than the norm given a diminishing pool of oceanic vessels as Cold War-era ships finally wear out with only limited replacement. Whilst the revamped Russian Navy is again a force to be reckoned with, its development is taking a different trajectory than, for example, China's progressively 'blue water' approach.

Accordingly, Table 2.4.6 summarising major Russian fleet constituents comes with the caveat that it excludes many of the smaller surface units upon which the fleet's power increasingly rests. The commentary on various combatant types that follows aims to provide some compensation for this deficiency. Given the very large range of ships currently under construction, no attempt has been made to provide an update on second-line and supporting vessel types.

Aircraft Carriers and Amphibious Ships: The modernisation of the sole Russian carrier *Admiral Kuznetsov* at the Zvezdochka repair yard in Murmansk continues to be beset by problems. In December 2019, a fire that broke out during welding operations killed two workers and has reportedly delayed the ship's return to service until 2023, a year later than previously scheduled. In spite of the ongoing difficulties the navy seems determined to complete the refit given lack of funds to embark on new aircraft carrier production in the foreseeable future.

The picture with respect to amphibious shipping is a little better. Sea trials of the second Project 11711 large landing ship *Petr Morgunov* commenced from the Yantar shipyard in Kaliningrad in

TABLE 2.4.6: RUSSIAN NAVY: SELECTED PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NUMBER[1]	TONNAGE	DIMENSIONS	PROPULSION	CREW	DATE
Aircraft carriers							
Aircraft Carrier – CV	Project 1143.5 **KUZNETSOV**	1	60,000 tons	306m x 35/73m x 10m	Steam, 32 knots	2,600	1991
Principal Surface Escorts							
Battlecruiser – BCGN	Project 1144.2 **KIROV**	2	25,000 tons	252m x 29m x 9m	CONAS, 32 knots	740	1980
Cruiser – CG	Project 1164 **MOSKVA** ('Slava')	3	12,500 tons	186m x 21m x 8m	COGAG, 32 knots	530	1982
Destroyer – DDG	Project 956/956A **SOVREMENNY**	c.2	8,000 tons	156m x 17m x 6m	Steam, 32 knots	300	1980
Destroyer – DDG	Project 1155.1 **CHABANENKO** ('Udaloy II')	1	9,000 tons	163m x 19m x 6m	COGAG, 29 knots	250	1999
Destroyer – DDG	Project 1155 **UDALOY**	c.8	8.500 tons	163m x 19m x 6m	COGAG, 30 knots	300	1980
Frigate – FFG	Project 22350 **GORSHKOV**	1	5,500 tons	135m x 16m x 5m	CODAG, 30 knots	210	2018
Frigate – FFG	Project 11366M **GRIGOROVICH**	3	4,000 tons	125m x 15m x 4m	COGAG, 30 knots	200	2016
Frigate – FFG	Project 1154 **NEUSTRASHIMY**	2	4,400 tons	139m x 16m x 6m	COGAG, 30 knots	210	1993
Frigate – FFG	Project 1135 **BDITELNNY** ('Krivak I/II')	c.2	3,700 tons	123m x 14m x 5m	COGAG, 32 knots	180	1970
Frigate – FFG	Project 2038.0 **STEREGUSHCHY**	6	2,200 tons	105m x 11m x 4m	CODAD, 27 knots	100	2008
Frigate – FFG	Project 11611 **TATARSTAN** ('Gepard')	2	2,000 tons	102m x 13m x 4m	CODOG, 27 knots	100	2002
Submarines							
Submarine – SSBN	Project 95/955A **YURY DOLGORUKY** ('Borey')	4	20,000+ tons	170m x 13m x 10m	Nuclear, 25+ knots	110	2010
Submarine – SSBN	Project 941 **DONSKOY** ('Typhoon')	1	33,000 tons	173m x 23m x 12m	Nuclear, 26 knots	150	1981
Submarine – SSBN	Project 677BDRM **VERKHOTURYE** ('Delta IV')	6	18,000 tons	167m x 12m x 9m	Nuclear, 24 knots	130	1985
Submarine – SSBN	Project 677BDR **ZVEZDA** ('Delta III')	1	12,000 tons	160m x 12m x 9m	Nuclear, 24 knots	130	1976
Submarine – SSGN	Project 855 **SEVERODVINSK** ('Yasen')	1	13,500 tons+	120m x 14m x 9m	Nuclear, 30+ knots	90	2013
Submarine – SSGN	Project 949A ('Oscar II')	c.8	17,500 tons	154m x 8m x 9m	Nuclear, 30+ knots	100	1986
Submarine – SSN	Project 971 ('Akula I/II')	c.10	9,500 tons	110m x 14m x 10m	Nuclear, 30+ knots	60	1986
Submarine – SSK	Project 677 **ST PETERSBURG** ('Lada')	1	2,700 tons	72m x 7m x 7m	Diesel-electric, 21 knots	40	2010
Submarine – SSK	Project 877/636 ('Kilo')	c.20	3,000 tons	73m x 10m x 7m	Diesel-electric, 20 knots	55	1981

Notes:
1 Table only includes main types and focuses on operational units and/or ships under active modernisation or refit.

December 2019 and she is expected to be delivered before the end of 2020. Two further, modified members of the class were laid down at the facility in April 2019. In contrast to the two earlier ships, these may have more of a classic amphibious transport dock configuration with a single, large superstructure block forward allowing more space aft for helicopter operation. Local press reports suggest that future construction of large amphibious warships may see further evolution, being based on a Project 23900 universal landing ship design, essentially a broadly similar replacement for the cancelled order for French *Mistral* type amphibious assault ships. It is believed that two vessels will be built at the Zaliv Shipyard in Crimea but there has yet to be official confirmation that work is underway.

The Project 11356M *Grigorovich* class frigate *Admiral Makarov* leads her sister *Admiral Grigorovich* through the Bosphorus on 28 February 2020 on a deployment from the Black Sea to the Mediterranean. The Russian Navy has been expanding its Mediterranean presence alongside its commitment to the Assad regime in Syria's civil war. *(Devrim Yaylali)*

Submarines: On 12 June 2020, the first Project 955A 'Borey II' strategic submarine, *Knyaz Vladimir*, was accepted into service at the Sevmash Shipyard in Severodvinsk. Her commissioning followed completion of an exhaustive set of trials that had included a successful test firing of a RSM-56 'Bulava' ballistic missile on 29 October 2019. She is expected to join the lead Project 955 'Borey' *Yuri Dolgoruky* in Russia's Northern Fleet, balancing the other two Project 955 boats deployed to the Pacific. A second Project 995A class unit, *Knyaz Oleg*, is expected to be launched at Severodvinsk during 2020 and three other submarines of the type are in various stages of construction. Russian sources suggest that twelve 'Boreys' – three Project 955s and nine Project 955As – may eventually be acquired to create a uniform underwater strategic force.

The Sevmash facility is also responsible for constructing the next generation of Project 885 'Yasen' series of nuclear-powered attack submarines. Initial trials of the second boat – the lead modified Project 885M variant *Kazan* – did not go according to plan and delivery is now expected in 2021 if a further round of testing scheduled for the second half of 2020 is successful. The third submarine in the series – *Novosibirsk* – was launched on 25 December 2019. Four other members of the class are currently being built and work on two others is expected to begin imminently.

Assembly of diesel-electric submarines is currently concentrated on the Admiralty Shipyard in St Petersburg. The facility recommenced building 'Kilo' class submarines for the Russian Navy in 2010, completing a batch of six Project 636.3 variants of the type for the Black Sea Fleet between 2014 and 2016. It is now working its way through a further batch of six for the Pacific Fleet. The first of these – *Petropavlovsk-Kamchatsky* – was commissioned towards the end of 2019 and a second, *Volkhov*, was launched in December 2019. However, it appears the shipyard may still be struggling to resolve problems with the long-delayed Project 677 'Lada' design, with the redesigned second of class *Kronstadt* still not in service as of mid-2020.

Surface Combatants: The second Project 22350 *Admiral Gorshkov* class frigate, *Admiral Kasatonov*, has continued to progress through its trials programme over the last year and was said to be close to final acceptance by June 2020. The previous month saw the launch of the third member of the class, *Admiral Golovko*, from St Petersburg's Severnaya Verf. Work is underway on three further vessels and a contract for an additional pair is expected imminently. Given further construction of further Project 11356M *Grigorovich* class frigates for Russian service seems unlikely, the multi-role *Gorshkov* class will increasingly become the focus of the fleet's oceangoing operations over the course of the next decade. Life extension work does continue to be performed on a small number of Soviet-era vessels. Notably, the Project 1164 cruiser *Moskva* was expected to return to operational service in mid-2020 whilst the reactivation of the larger Project 1144 battlecruiser *Admiral Nakhimov* continues at Sevmash. However, the majority of these ships are now well past their 30th birthdays, making further modernisation of questionable value.

Severnaya Verf's other major programme of surface combatant construction is for the Project 20380/85 series of multi-purpose light frigate-sized corvettes, which are also built by the Amur Shipyard in Russia's Far East. Like many Russian shipbuilding programmes, this has taken far longer to realise than initially envisaged but is seemingly drawing to a conclusion. Severnaya Verf has now put five of the six Project 20380 *Steregushchy* class ships allocated to it into the water following the launch of *Retiviy* in March 2020. It also launched *Provorniy*, the latter of

a pair of Project 20385 variants, the previous September. Meanwhile, *Aldar Tsydenzhapov*, the third of four Project 20380 ships ordered from the Amur Shipyard, was rolled out on 12 September 2019. Future light frigate construction is likely to transition to the much-modified modular Project 20386 design. The prototype, *Merkuriy*, is being built at Severnaya Verf and should be launched during 2021.

An increasing portion of the Russian Navy's above water firepower is comprised of a series of smaller corvettes armed with small numbers of long range anti-shipping and land attack missiles. These originated with the c. 950-ton Project 21631 'Buyan M' small missile ships built for service in the inland Caspian Sea and other littoral waters. Eight had been delivered as at mid-2020 with another four scheduled for completion at roughly annual intervals by the inland Zelenodolsk yard on the Volga River. They are now being followed by the broadly similar-sized but more seaworthy Project 22800 'Karakurt' corvettes that are also characterised by an ability to undertake long-range surface strikes. At least eighteen of these have been ordered from six yards, with *Sovetsk* joining sister *Mytishchi* in operational service at the end of 2019. There have been suggestions that the basic hull might also be used as the basis for a differently configured anti-submarine vessel, echoing a design solution also used in Soviet times.

A somewhat different design approach is evident in the Project 22160 offshore patrol ships. Two of these have been delivered to date and a further four are being built. The ships are similar to 'Western' offshore patrol vessels in being designed for long-endurance constabulary missions in a wide range of sea states but can be equipped with a range of containerised modular equipment to boost their warfighting potential.

A feature of most of the surface vessel designs discussed above is their use of a standardised vertical launch system – known as a universal ship firing complex – that, in similar fashion to the US Navy's Mk 41, can be used in conjunction with a wide array of missiles in the navy's arsenal. This holds out the prospect that many will ultimately be equipped with the next-generation 3M22 Zircon hypersonic cruise missile, which can reportedly reach speeds of up to Mach 9. In early January 2020, the missile undertook its first test launch from a warship when the weapon was fired at a far distant land target from *Admiral Gorshkov* whilst the ship was operating in the Barents Sea. The aim behind Zircon appears to be based on developing a missile that has a much greater chance of penetrating enemy defences than existing types, thereby compensating for the relatively limited number of missiles that can be deployed on the navy's new generation of smaller ships.

Notes

1. M. Guillou was quoted by Christina Mackenzie in ''Europeans don't have a choice': Naval Group boss pushes for shipyard consolidation' posted to the *Defense News* site – www.defensenews.com – on 21 February 2020.

2. The European Union's Permanent Structured Cooperation is a Treaty-based process to deepen defence cooperation amongst participating EU Member States to assist joint development of defence capabilities. Commitments undertaken by the participating Member States are legally-binding on them.

3. Mr. van Ameijden made the comment in another *Defense News* article, 'Toward a "Naval Airbus"? Not so fast' posted on 24 February 2020 and written in response to M. Guillou's comments referenced above.

4. For a more detailed analysis of the likely consequences of the deal on German shipbuilding, please see Uwe Mergener, 'The Way Ahead for German Shipbuilding' posted to the *European Security & Defence* site – euro-sd.com – on 12 June 2020. Referencing the previous, ultimately unsuccessful consolidation of much of the German naval sector under TKMS, Herr Mergener asks the valid question of, '...whether TKMS itself is able to once again master such a process rather than become part of it'.

5. The two ships' names commemorate officers involved in the successful attack on the British cruiser *York* and other shipping in Suda Bay, Crete on 26 March 1941.

6. See *Linee Di Indirizzo Strategico 2019-2034* (Rome: Marina Militare, 2019) available in Italian by searching: www.marina.difesa.it

7. The geographically separated Riva Trigoso and Muggiano yards are effectively run as an integrated entity, with fabrication and assembly at Riva Trigoso followed by final outfitting and systems commissioning at Muggiano.

8. The Comptroller & Auditor General, *Carrier Strike – Preparing for deployment* (London: National Audit Office, 2020) available by searching the NAO's website at: www.nao.org.uk

9. The Comptroller & Auditor General, *Managing infrastructure projects on nuclear-regulated sites* (London: National Audit Office, 2020).

10. Sir John Parker prepared an independent report on naval shipbuilding in the United Kingdom for the government in 2016, which subsequently formed the basis of a National Shipbuilding Strategy published the following year. The Type 31 programme was seen as a pathfinder for implementing the strategy's principles. Sir John was subsequently asked to conduct a review of progress of implementation, which was concluded in the second half of 2019.

11. The three Batch I 'River' class vessels and the subsequent modified variant *Clyde* were originally supplied to the Ministry of Defence by their builder, the then VT Group, under innovative leasing and logistic support arrangements. The three initial ships were subsequently purchased outright but *Clyde* remained on lease for the duration of her Royal Navy service.

12. Jaime Karremann's *marineschepen.nl* website remains an excellent source of information on the Royal Netherlands Navy, providing much additional information on the projects referenced in this section.

13. Devrim Yaylali's *Bosphorus Naval News* blog at: turkishnavy.net/ remains the premier English language source for Turkish Navy developments. The author thanks Mr Yaylali for his assistance in commenting on this section.

14. Norway has published an English-language summary of the new plan, *The defence of Norway: Capability and readiness – Long Term Defence Plan 2020* (Oslo: Norwegian Ministry of Defence, 2020) available by searching the Norwegian government's website at www.regjeringen.no.

15. The report – published on 8 November 2019 – is available on the Authority's website, www.havarikommisjonen.no.

16. The deployment – conducted with the aid of three support vessels – is claimed to be the first such voyage by Russian ships since the nineteenth century.

17. See Henry Foy, 'Russia to invest $500m in Syrian port of Tartus' posted to *The Financial Times* website – www.ft.com – on 17 December 2019.

2.4A FLEET REVIEW

Author:
Dieter Stockfisch

THE ROYAL SWEDISH NAVY (SVENSKA MARINEN)

Facing rising tensions in the Baltic Sea

The Baltic Sea region has been of significant strategic interest for Sweden throughout the ages. The Baltic environment, of itself, presents a significant challenge for maritime forces seeking to operate in and from the sea, whilst also providing ample opportunities for those seeking to deny access to the region. Notably, the Baltic Sea can be classified as an 'extreme littoral' environment typified by shallow water and narrow channels. It is in these conditions that the *Svenska Marinen* (SM) must operate.

The Swedish Baltic Sea coastline extends all the way from the Bothnian Bay in the east to the Skagerrak in the west, a distance of more than 1,500km.[1] With its exposed geo-political position, Sweden – in line with many other countries in the region – needs to view national security as a significant concern. Sweden's naval forces are highly sophisticated but relatively small in size and capacity. Consequently, the SM has placed a high premium on developing unique three-dimensional underwater, surface and above-surface capabilities optimised for combat in its adjacent coastal and sea areas.

The SM's naval and amphibious units – in concert with the country's air and land forces – must be able to uphold Sweden's territorial integrity in peacetime and to defend the country against future threats, with force if necessary. They must be capable of being used to support the civil community, whilst also being suitable for international deployment. This chapter looks at how the SM is organised and structured to meet these multifaceted objectives.

The Swedish *Visby* class corvette *Karlstad* pictured at speed during the NATO-sponsored 'Trident Junction' 2018 exercises. Sweden is increasingly turning back to a focus on national defence in the face of growing regional challenges, with increasing collaboration with neighbours forming part of its response. *(Norwegian Armed Forces/ Marius Vågenes Villanger)*

HISTORICAL BACKGROUND

The SM has a long history and tradition. Early Swedish kings protected the coastline and undertook expeditions overseas through a system of conscription of both boats and their crews known as '*ledung*'. However, the current navy's roots are commonly regarded as tracing their origins to 7 June 1522. It was then, in the aftermath of the dissolution of the Kalmar Union with Denmark and Norway, that Gustav Vasa acquired a number of ships from the Hanseatic League town of Lübeck and brought them into Swedish waters.[2] Subsequently Swedish power expanded to the extent that it became the

The *Vasa*

Vasa is an early seventeenth-century Swedish warship built at the then navy yard in Stockholm on the orders of the then King of Sweden, Gustav II Adolf (Gustavus Adolphus). Powerfully armed with 64 bronze guns on two decks, she was also richly decorated as a symbol of the king's naval ambitions. However, *Vasa* was dangerously unstable, with too much weight in the upper structure of the hull. The ship foundered only a few minutes into her maiden voyage on 10 August 1628 after encountering winds little stronger than a breeze.

Falling into obscurity after the salvage of many of her guns, *Vasa* was relocated in the second half of the 1950s just outside Stockholm harbour. Salvaged with a largely intact hull in 1961, she is now housed in the Vasa Museum in Stockholm. One of Sweden's most popular tourist attractions, she has become a widely-recognised symbol of the period when Sweden rose to become a great European power.

dominant power in the Baltic during the seventeenth century, gaining territory that encompassed the sea on all sides. The iconic warship *Vasa* dates from this period.

The growth of Russian power and the Great Northern War of 1700–21 marked the end of Swedish regional ascendency, a decline subsequently confirmed by further territorial losses in the Napoleonic Wars. From the nineteenth century onwards, the SM became increasingly focused on the territorial defence of the Swedish littoral from external aggression and the protection of its commercial shipping lanes. This eventually saw the core of the fleet focused on a flotilla of powerful coast defence battleships.

The fleet's structure continued to evolve after the Second World War, most notably through the Naval Plan 60 (*Marinplan* 60) strategy. This emphasised a 'light navy' structure built around fast attack craft, submarines and flexible coastal defences at the expense of heavier units. Sweden's last big ship, the cruiser *Göta Lejon*, was sold to Chile in 1970. This approach was developed further with the 1972 Defence Bill. This saw the effective abandonment of sea lane protection and its associated surface escorts and in favour of a further concentration on littoral defence against the Soviet threat. The famous 'Whiskey on the Rocks' incident of October 1981 – when a Project 613 submarine became stranded close to the Karlskrona naval base – resulted in a particular focus on anti-submarine defence for the remainder of the Cold War.

The end of the Cold War meant that the navy was increasingly impacted by the 'peace dividend' that swept the European democracies whilst also seeing a reorientation towards international stabilisation missions beyond Sweden's borders. A series of defence bills produced significant changes to the overall size and structure of the Swedish Armed Forces. The previous anti-invasion stance was progressively abandoned and defence spending fell from c. 2.5 percent at the time the Soviet Union collapsed to a little more than 1 percent of GDP. This process was also reflected in the abolition of peacetime conscription in the 2009 Defence Bill. The navy was reduced to a core focused on four active submarines, seven corvettes and seven mine countermeasures vessels, a force level which has largely held good to the present day. Internationally, the deployment of the corvettes *Gävle* and *Sundsvall* off Lebanon's coast in 2006 and 2007 to support the United Nation's UNIFIL mission and subsequent participation in the European Union Operation 'Atalanta' in the Indian Ocean were a major sign of changed priorities.

The subsequent re-emergence of a Russian threat – amplified by a well-publicised exercise against Swedish airspace and the incursion of an unidentified submarine into territorial waters – has started to reverse post-Cold War thinking. In 2015, Swedish parliamentarians agreed the latest defence bill, covering the period 2016–20.[3] Placing an emphasis on rebuilding Sweden's warfighting capabilities as part of a new 'total defence' strategy coordinating military and civil defence, the bill heralded a return to a regional, Baltic focus. Anti-submarine capabilities were one of a number of areas given particular priority. In a further development announced in March 2017, the government recommenced a limited form of conscription from 1 January 2018.

A picture of the Swedish coastal defence battleship *Sverige* at Stockholm in May 1934. An increasing focus on territorial defence saw the fleet build a series of powerful ships of this type. *(US Naval Heritage & History Command NH71789)*

RESPONSIBILITIES AND MISSIONS

The ability to maintain a credible military defence is a prerequisite of Sweden's total security policy. In turn, this requires the Swedish Armed Forces to be sufficiently available and prepared in peace so as to

The corvette *Sundsvall* – seen here with a German MCMV in 2009 – is typical of the 'light navy' structure that the SM gravitated towards in course of the Cold War. *Sundsvall* is one of a number of SM ships that have subsequently participated in post-Cold War stabilisation missions and a major upgrade will allow her to serve through the decade. *(German Armed Forces)*

be rapidly able to assume a higher degree of readiness if the situation so demands. The overall mission to secure Sweden and the country's freedom by:

- Protecting Sweden's sovereignty and national interests both inside and beyond Swedish territory.
- Preventing and managing conflicts and war.
- Protecting Sweden's freedom of action when faced with political and military pressure.
- Assisting the civil authorities as necessary.

The SM's responsibilities are subordinate to these overall aims and are effectively focused on ensuring Sweden's territorial waters and coastline remain under Swedish control. A range of surface, underwater and amphibious forces are available to perform these tasks, described more fully below.

ORGANISATIONAL STRUCTURE

The Swedish Armed Forces are headed by the Supreme Commander – currently former Swedish Air Force Chief of Staff General Micael Bydén – who is assisted by the group of senior staff that comprise the Armed Forces Management (FML). He is based at Armed Forces Headquarters in Stockholm. Following a decision taken in 2018 to increase organisational resilience in case of attack, separate headquarters organisations have been re-established for the three branches of the armed forces, with the new Swedish Naval Staff in the course of moving to the underground base facility at Muskö that was first constructed during the Cold War era. The current Chief of the Navy is Rear Admiral Ewa Ann-Sofi Skoog Haslum, who assumed the role on 21 January 2020. She is probably the first professional female head of a modern navy.

Comprising a little over 5,000 personnel –

The MCMV *Koster* is one of seven operational minehunters in the SM's force structure. These are allocated to the two Naval Warfare Flotillas based at Karlskrona and at Bega, near Stockholm. *(Copyright Saab AB/Peter Nilsson)*

The reconstructed Swedish submarine *Gotland* photographed in October 2018. Sweden's submarines serve with the First Submarine Flotilla based at Karlskrona. *(Copyright Saab AB)*

including some 1,500 reservists – the navy is organised into a number of flotillas, battalions and support units. The most significant are:

NAVAL WARFARE FLOTILLAS

The Naval Warfare Flotillas – also known as Naval Combat Fleets – are capable of monitoring sea areas, maritime traffic and fisheries, and of engaging surface and underwater targets both in coastal waters and on the open sea, in addition to possessing a mine warfare capability. Two of these flotillas are operational, viz.

- **Third Naval Warfare Flotilla**: Based at Karlskrona, the flotilla comprises the 31st Corvette Division with *Visby* class corvettes and *Stockholm* class patrol vessels; the 33rd Mine Clearance Division with *Koster* and *Styrsö* class MCMVs and the 34th Support Division focused on the former minelayer *Carlskrona.*
- **Fourth Naval Warfare Flotilla:** Based at Berga near Stockholm as part of the Berga-Muskö Haninge garrison, the flotilla encompasses the 41st Corvette Division with *Visby* and *Gävle* class corvettes, the 42nd Mine Clearance Division with *Koster* and *Styrsö* class MCMVs and the 43rd Support Division with the command and support ship *Trossö.* The flotilla is also responsible for the

The 6,200-ton submarine rescue vessel *Belos* – currently the largest vessel in the SM – serves with the First Submarine Flotilla and is based at Karlskrona. As a result of post-Cold War defence reductions, naval base infrastructure has become focused on Karlskrona, which acts as headquarters for the remaining facilities based at other locations. *(Swedish Armed Forces/Rebecka Signaes)*

44th Clearance Diving Division based at Skredsvik, north of Gothenburg.

SUBMARINE FLOTILLA

The sole, First Submarine Flotilla is capable of the covert monitoring of sea areas, intelligence-gathering and the engagement of both underwater and surface targets. Based at Karlskrona, the flotilla currently comprises boats of the *Södermanland* and *Gotland* classes, as well as the submarine rescue ship *Belos* and the intelligence-gathering vessel *Orion.*

AMPHIBIOUS REGIMENT

Capable of monitoring coastal and inshore areas and of engaging both surface and underwater targets, the Amphibious Regiment is the heir to the now disbanded Swedish Coastal Artillery first formed in 1902.[4] Based at Berga, Gothenburg and on the island of Gotland, the Regiment comprises around 950 marines and encompasses the Second Amphibious Battalion, the 17th Amphibious Patrol Boat Company and the 132nd Naval Security Company, as well as three Home Defence Battalions. The amphibious forces are equipped with large numbers of CB-90 combat boats and 'G' class personnel landing craft, as well as a range of other vessels that include a handful of larger Type 80 patrol boats and three Griffon 8100 TD hovercraft. Other equipment includes mobile surface-to-surface missile launchers and the ability to lay controlled mines.

NAVAL BASE

Following the post-Cold War defence reductions, the Swedish naval base infrastructure has been focused on the main facility at Karlskrona, which acts as headquarters for the Berga-Muskö complex near Stockholm as well as for facilities at Gothenburg and other locations. The base organisation is also responsible for a base protection company, a maritime information company that monitors Swedish territorial waters, harbour support operations and a logistics company that supports units with food and other supplies. These units operate a number of service and harbour support

The CB-90 combat boats – more than a hundred of which are currently in service – are the mainstay of the SM's amphibious forces. *(Copyright Saab AB)*

vessels, including tug and supply boats and the torpedo recovery vessel *Pelikanen.*

Another important facility headquartered at Karlskrona is the Naval Warfare Centre. This is responsible for nearly all the SM's naval training. It also encompasses the Swedish Armed Forces diving and naval medical centres, as well as being responsible for liaison with the Swedish Defence Materiel Administration (FMV) with respect to shipbuilding and reconstruction. The centre operates a number of training vessels, including the schooners *Gladan* and *Falken*.

PRINCIPAL UNITS

A summary of the SM's principal units is provided in Table 2.4A.1. Current force structure remains based on that agreed in the 2015 Defence Bill. This mandated that the navy would maintain five *Visby* class corvettes, five *Koster* class MCMVs and two *Spårö/Styrsö* class mine-clearance diver support vessels, as well as one *Gotland* class and one *Södermanland* class submarine, in operational service over the 2016–20 timeframe.[5] During this period midlife upgrades would be undertaken on two *Göteborg/Gävle* class corvettes and two additional *Gotland* class submarines to maintain stable core fleet numbers. These totals exclude two additional *Stockholm* class corvettes that have been reclassified as patrol vessels but retain much of their original armament.

Table 2.4A.1: SWEDISH NAVY – PRINCIPAL UNITS AS AT MID 2020

TYPE	CLASS	NO.	YEAR[1]	TONNAGE	DIMENSIONS	SPEED	PRINCIPAL ARMAMENT
Submarines (4+2)[2]							
Submarine (SSK)	**GOTLAND** (Modified)	2	1996	1,700 tons	62m x 6m x 6m	20+ knots	6 x TT, torpedoes & mines
Submarine (SSK)	**GOTLAND**	1	1996	1,600 tons	60m x 6m x 6m	20+ knots	6 x TT, torpedoes & mines
Submarine (SSK)	**SÖDERMANLAND**	1	1987	1,600 tons	61m x 6m x 6m	20+ knots	9 x TT, torpedoes & mines
Two of the *Gotland* class submarines completed midlife upgrades, including a hull plug, in 2018 and 2019. An additional *Södermanland* class submarine is in reserve. Two A26 *Blekinge* class boats are under construction.							
Corvettes (9)							
Corvette (FF)	**VISBY**	5	2009	650 tons	73m x 10m x 3m	35+ knots	2 x quad SSM, 1 x 57mm, 4 x TT, 1 x helo (platform)
Corvette (FF)	**GÖTEBORG**	2	1990	425 tons	57m x 8m x 2m	30+ knots	4 x twin SSM, 1 x 57mm, 1 x 40mm, 4 x TT, 4 x A/S mortars
Corvette (FF)	**STOCKHOLM**	2	1985	375 tons	50m x 8m x 3m	30+ knots	4 x twin SSM, 1 x 57mm, depth charges
The two *Stockholm* class vessels are officially classified as patrol ships. Two additional *Göteborg* class ships have been disarmed.							
Mine Countermeasures Vessels (7)							
MCMV	**KOSTER**	5	1984	375 tons	48m x 10m x 2m	15 knots	1 x 40mm, depth charges
MCMV	**SPÅRÖ**	2	1996	200 tons	36m x 8m x 2m	13 knots	Light weapons
The two *Spårö* class vessels act as diving support ships. Two sister-ships – *Styrsö* and *Skaftö* – have been relegated to subsidiary roles. Two *Landsort* class MCMVs – formerly sisters of the *Koster* class – have been disarmed.							
Patrol Boats (11)							
PB	Type 80 TAPPER	5	1993	60 tons	23m x 5m x 2m	25 knots	Light weapons & depth charges
PB	Type 82 TAPPER	6	1993	60 tons	23m x 5m x 2m	25 knots	Light weapons. Can be fitted with depth charges
The Type 80 boats are deployed with the Amphibious Regiment for A/S duties. The Type 82 boats have been modified for passive sonar surveillance and serve with the two Naval Warfare Flotillas.							
Major Support Vessels & Auxiliaries (4+1)							
Support Ship (AG)	**CARLSKRONA**	1	1982	3,600 tons	106m x 15m x 4m	20 knots	2 x 40mm, 1 x helo (platform)
Support Ship (AG)	**TROSSÖ**	1	1998	2,100 tons	72m x 13m x 5m	14 knots	Light weapons
Intelligence Ship (AG)	**ORION**	1	1984	1,200 tons	61m x 12m x 4m	12 knots	Unarmed
Salvage Ship (ARS)	**BELOS**	1	1992	6,200 tons	105m x 18m x 5m	13 knots	Unarmed
A replacement for *Orion* is currently in the course of construction. Other support and auxiliary ships in Swedish Navy service include the research vessel *Fursund*, the torpedo recovery vessel *Pelikanen* and a number of tugs and light transports. The Naval Warfare centre maintains five *Altair* class navigation training vessels and the schooners *Gladan* and *Falken*.							

Amphibious Vessels

In addition to its five Type 80 patrol boats, the Amphibious Regiment operates more than 100 of the 147 CB-90H and CB-90HS assault boats delivered from 1989 onwards (many of the remainder serve with the Naval Base Organisation and the Home Guard). It also has some 100 Watercat M8 'G' Boat light landing craft, two command boats, 16 light support craft, the 300-ton landing ship *Loke* and three Griffon 8100 TD hovercraft.

Notes;

1. Date relates to the date the first ship of the class entered service with the Swedish Navy. In some cases, these ships are now retired.

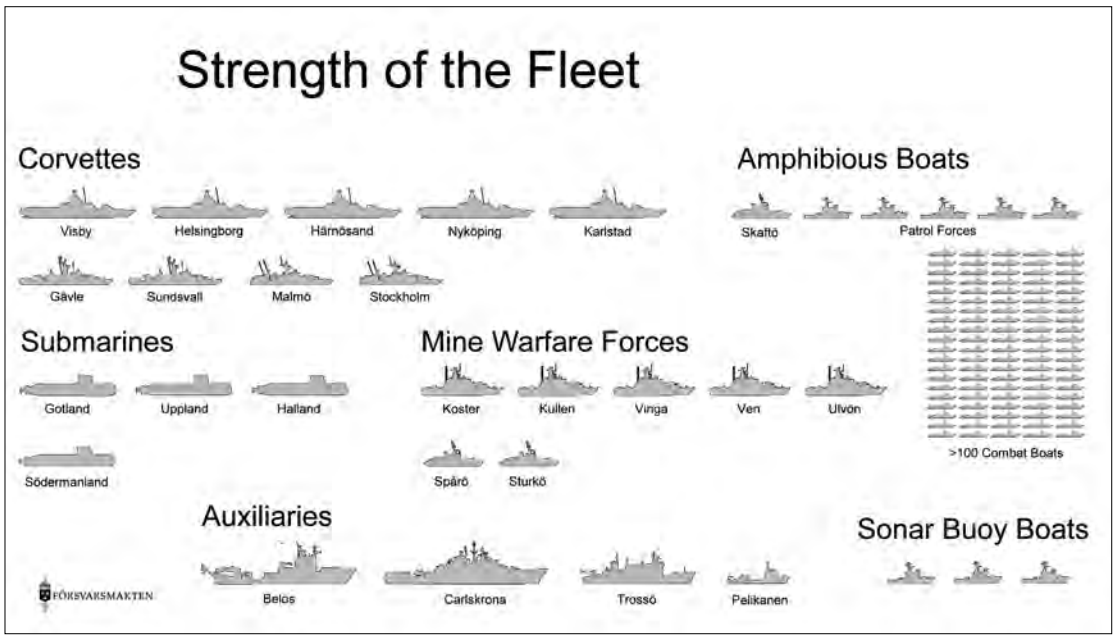
2. Second number refers to ships of the type/class currently under construction or on firm order

The main naval emphasis in the 2015 Defence Bill was enhancing the fleet's anti-submarine capabilities. This is reflected in the decision to undertake the *Gävle* class corvette modernisation, providing them with new anti-submarine capabilities including sensors and command and control systems. It was also decided to extend the lives of the small Type 80 *Tapper* class patrol boats. Seven are being modified with new anti-submarine weapons and four being rebuilt into buoy-monitoring boats.[6] This increased the number of anti-submarine platforms compared to previous planning. New mobile sensors are also being taken into service and mine-systems being kept operational to support anti-submarine surveillance capabilities.

In general terms, the SN's surface ships are mostly small, relying on agility and flexibility to undertake their allotted functions. However, the new *Visby* class corvettes are larger, multi-mission ships with greater endurance and seaworthiness that place a heavy emphasis on all-round stealth for survivability.[7] A similar approach can be seen in the navy's underwater flotilla. The latest *Gotland* class boats introduced new levels of submerged endurance for a diesel-electric submarine when first delivered by virtue of their Stirling air-independent propulsion (AIP).

The CB-90H series of combat boats remain the mainstay of the amphibious forces. A total of 147 of these all aluminium fast assault craft, heavily reinforced for landings on unprepared beaches, were delivered between 1989 and 2003. Over a hundred remain in front-line naval service. Capable of speeds in excess of 30 knots, the boats are designed to transport a half company of eighteen marines (the 'H' in the designation refers to half) in addition to their three/four-strong crews. Twenty-seven of the total are fitted to an HS standard with enhanced splinter and nuclear biological and chemical (NBC) protection for international operations. Their usual roles in territorial waters are scouting and the rapid transportation of troops. Normal armament is three 12.7mm machine guns but mines and depth charges can also be deployed.

The SN's helicopter forces were combined into an integrated helicopter wing under the control of the Swedish Air Force in the 1990s. The wing operates a total of three squadrons that are currently equipped with eighteen HPK14 (NH Industries NH90), twenty HPK15 (Leonardo Helicopters AW109) and sixteen HPK16 (Sikorsky UH-60 Black Hawk)



An infographic setting out the Swedish Navy's principal units as of 2020. A large number of smaller vessels are omitted. *(Swedish Armed Forces)*

The 2015 Defence Bill decided to extend the lives of the small Type 80 *Tapper* class patrol boats, which are either being modernised with new anti-submarine weapons or re-equipped as sonar buoy monitoring boats. This is *Trygg* in April 2019. *(Swedish Armed Forces/Hampus Hagstedt)*

The most significant recent modernisation project undertaken by the Swedish Navy has been the implementation of mid-life upgrades for two of the three *Gotland* class submarines, including addition of a c. 2m hull plug for new equipment. A similar upgrade of the third boat has been proposed for the 2021–5 period. *(Swedish Armed Forces/Rebecka Signaes)*

rotorcraft. Of these, eight of the AW109s have been modified to be operated from the *Visby* class corvettes and *Carlskrona*, whilst nine of the NH90s are equipped with sonar and radar systems for anti-submarine warfare.

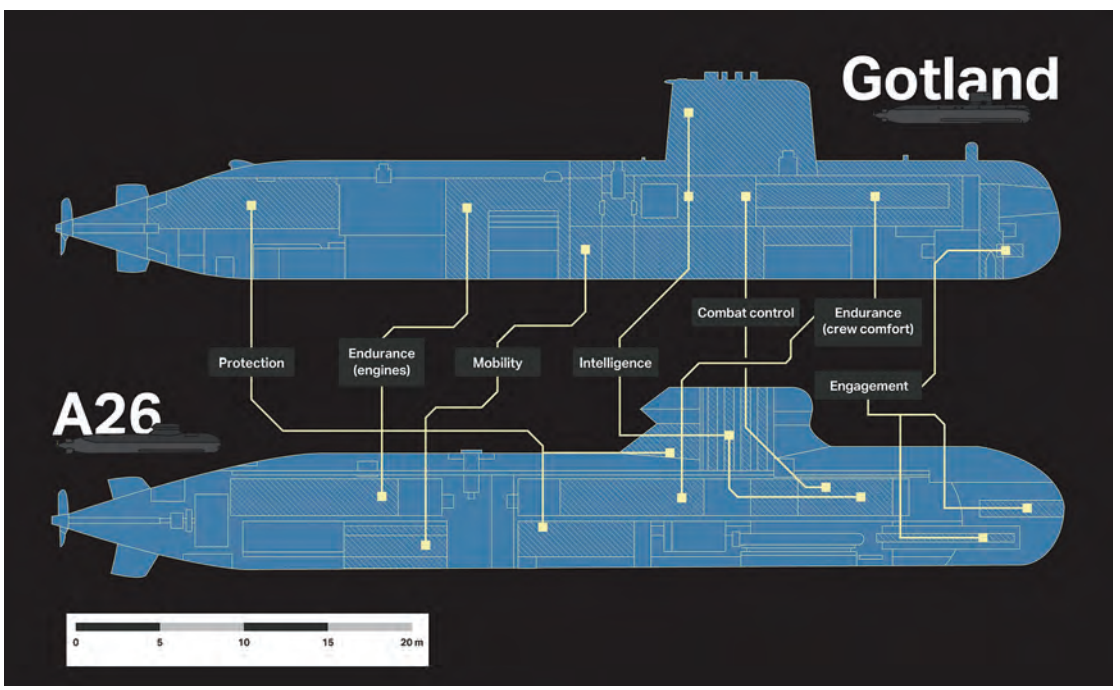
MODERNISATION AND PROCUREMENT

The 2015 Defence Bill provided continued support for a number of previously-planned modernisation and new procurement projects as well as initiating new programmes. The most significant project undertaken during the 2016–20 timeframe has been the mid-life update of two of the three *Gotland* class submarines – *Gotland* and *Uppland* – under a SEK2.1bn (c. US$210m) contract with Saab announced in June 2015. The refit involved the insertion of a c. 2m hull plug to make space for additional equipment, installation of the latest Mk 4 iteration of the Stirling AIP plant, a new suite of masts and other sensor and communications upgrades. Both updates have now been completed, with the return of *Gotland* to the fleet in 2018 followed by the relaunch of *Uppland* in June 2019. Many of the technologies being inserted in the upgraded submarines are also to be used in the two new A26 class boats *Blekinge* and *Skåne*, which were also ordered in June 2015 at a total cost of SEK7.6bn (c. US$760m) and are expected to enter service in the middle of the current decade.

In addition to the surface fleet modernisation programmes already mentioned, the Amphibious Regiment will benefit from an order for eighteen new CB-90 HSM variants under a contract signed in 2017. The first of these was handed over to the FMV in October 2019 and the remainder are expected before the end of the year. Also expected within the next twelve months is delivery of the new signals intelligence (SIGNIT) vessel *Artemis*. She will replace the 1980s-era *Orion*, which will be decommissioned.

The period of the current Defence Bill has also seen signature of contracts for development and production of a new lightweight torpedo – Torped 47 – that is expected to enter service from 2023 and for the Mk 4 variant of the Robotsystem 15 (RBS-15) anti-shipping missile.

Looking to the future, a number of key procurement decisions need to be taken in the coming 2021–5 period, including significant upgrades for the *Visby* class and eventual replacements for the two *Gävle* class corvettes. The Defence Commission tasked with examining future security policy also



They midlife upgrades being performed on the *Gotland* class are being followed by construction of a pair of new A26 *Blekinge* class boats. This graphic illustrates how equipment destined for the *Blekinge* class will be first trialled in the updated *Gotland*s. *(Copyright Saab AB)*

A CB-90 combat boat equipped with the Trackfire remote weapons system. This is one of a number of upgrades that new CB-90 HSM variants currently being delivered to the SM will benefit from. *(Swedish Armed Forces)*

recommended a midlife update for the third *Gotland* class submarine (to increase active submarine numbers to five), the deployment of a new land-based anti-shipping missile and the enhancement of mine warfare capabilities in its final report to the Minister of Defence in May 2019.[8] This would suggest further upgrade or replacement of the *Koster* class.

THE SWEDISH COAST GUARD

The Swedish Coast Guard is not officially a part of the navy. Instead, it operates as a civil government

The lead *Visby* class corvette operating with a HPK15 (Leonardo Helicopters AW109) helicopter. A decision on significant upgrades to the five members of the class needs to be taken soon. *(Copyright Saab AB)*

The civilian Swedish Coast Guard is not part of the Swedish Navy but plays an important complementary role ensuring the country's maritime security. This picture shows the combined environmental protection and surveillance vessel KBV 003 *Amfitrite* on exercise with a CB-90 combat boat. *(Swedish Armed Forces)*

The Swedish *Visby* class corvette *Karlstad* berthing alongside NATO ships in Trondheim in October 2018. Whilst Sweden continues to maintain a policy of avoiding strictly military alliances, collaboration with neighbours on both a bilateral and collaborative basis has increased in recent years. *(Norwegian Armed Forces/Torbjørn Kjosvold)*

agency under the auspices of the Ministry of Justice. However, its activities are coordinated with those of the Swedish Armed Forces in a number of areas and it plays an important role within the country's total defence concept. Operating along Sweden's entire coastline, the coast guard undertakes monitoring, assistance and rescue operations to protect both life and the environment at sea in Sweden's territorial waters and broader economic zone.

The Swedish Coast Guard operates from around twenty coastal stations spread from Strömstad in the west to Luleå in the north, as well as from an aviation station at Skavsta Airport in Nyköping. The service operates around thirty larger patrol and environmental protection vessels as well as numerous inshore patrol boats. There are also five hovercraft, used largely in northern Sweden where they can easily travel over land, water and ice. All the vessels are unarmed, the crews themselves being equipped with light arms equivalent to those used by the Swedish Police. The Coast Guard Air Patrol branch operates three Bombardier Dash 8 Q-300 aircraft for maritime surveillance. This is conducted along the Swedish coast by both day and night.

FLEXIBLE NEUTRALITY AND PARTNERSHIP

Sweden's policy of neutrality in armed conflicts – stretching from the end of the Napoleonic Wars through two World Wars to beyond the end of the Cold War – has been a major influence on its security and, consequently, naval policy. The first half of the 1990s saw changes in this approach, notably as a result of accession to the European Union in 1995. Whilst officially remaining free of strictly military alliances, it has also drawn increasingly close to NATO on a practical level. This cooperation can be traced to Sweden's membership of the Partnership for Peace programme in 1994 and has subsequently extended to a number of other collaborative ventures.

The initial focus of Sweden's 'flexible neutrality' was participation in the international stabilisation missions that typified the immediate post-Cold War era. This included the deployment of naval units in the European Union's 'Atalanta' mission previously mentioned. Another example has been the contribution of various Swedish Armed Forces' assets to NATO-led operations from 1995 onwards, when a Swedish battalion served alongside alliance peacekeepers in Bosnia and Herzegovina. For the navy,

An unidentified *Visby* class corvette pictured against an evening sky. The SM's reorientation back to the Baltic is potentially beneficial for regional stability. *(Swedish Armed Forces/Magnus Jirlind)*

collaboration has also seen engagement in a wide range of training exercises. These have included the annual 'Baltops' and 'Northern Coasts' serials in the Baltic, as well as those further afield such as the combined forces 'Joint Warrior' series in British waters. Participation in these manoeuvres has allowed the SM to benchmark itself against NATO and other European navies and to operate more smoothly with multinational task groups.

Rising tension with Russia has recently seen the focus on partnerships shift from stabilisation abroad to regional security at home. The SM has particularly strong links with the neighbouring Finnish Navy, as evidenced by the recent creation of a joint Swedish-Finnish Naval Task Group (SFNTG). This achieved initial operating capability in 2017 and will reach its full potential by 2023. The task force's development is set against a background of steadily increasing collaboration with the wider Finnish defence establishment, as most recently demonstrated by signature of a memorandum of understanding on defence cooperation by the two countries' defence ministers in June 2018. Closer links are also being developed more widely across the Baltic. One example is the sharing of sea surveillance and situational awareness under the Surveillance Cooperation Baltic Sea (SUBCAS) arrangements, which encompass many of the Baltic nations, as well as the United Kingdom. However, the SM and wider defence establishment are clear in stating that these growing examples of regional collaboration do not extend to the creation of mutual defence obligations.

CONCLUSION

The Baltic Sea region is emerging as one of the key friction zones between a revitalised Russia and its 'Western' rivals. Since the accession of Poland and the Baltic States to the European Union in 2004, the Baltic Sea has been almost entirely bordered by EU countries, many of which are also NATO members. Russian territory around St Petersburg and its Kaliningrad enclave form the only exceptions to this rule. Against this, the Kaliningrad oblast forms the focal point of a powerful Russian anti-access/area-denial (A2/AD) network across the region that would challenge NATO's ability to reinforce the Baltic States and to operate at and from the sea during a crisis.

The SM's strong reorientation back to the Baltic region – alongside a similar shift in broader Swedish defence policy – is an important development in these circumstances and one that has the potential to do much to bolster regional defence capabilities. However, much will depend on the country's willingness to continue the increased regional cooperation and coordination that has been a marked recent trend in order to lay the ground work for a cohesive multinational response should a crisis arise.

Notes

1. Sweden's overall coastline – some 3,200km in length – includes that of many islands.

2. Gustav Vasa, crowned King Gustav I of Sweden in 1523, led Sweden's secession from the Kalmar Union and is often regarded as the founder of modern Sweden.

3. An English-language summary of the main elements of the bill, *Sweden's Defence Policy 2016 to 2020* (Stockholm: Government of Sweden, 2015) can be found by searching the Government Offices of Sweden website at: www.government.se.

4. The replacement for the Coastal Artillery was the Amphibious Corps but – with the reduction of the force to just one regiment in subsequent defence bills – the term has fallen out of favour.

5. There are two *Södermanland* class submarines but the second, *Östergötland*, is in long-term reserve.

6. There is some discrepancy in the information in the 2015 defence policy documentation and subsequent information posted to the Swedish Armed Forces' website on Type 80 modernisation. The latter suggests six of the class will be fitted as specialised Type 82 surveillance vessels equipped with Type 911 passive sonar and various types of sonar buoy, with five being retained as anti-submarine hunters under the Amphibious Regiment's control.

7. For further details on the *Visby* class see Guy Toremans', 'Sweden's *Visby* Class Corvettes: Stealth at all Levels' in *Seaforth World Naval Review 2012* (Barnsley: Seaforth Publishing, 2011), pp.149–65.

8. An English-language summary of the report, *The Swedish Defence Commission's white book on Sweden's Security Policy and the Development of the Military Defence 2021-2025* (Stockholm: Swedish Defence Commission, 2019) is accessible by searching www.government.se.

3.1 SIGNIFICANT SHIPS

AMERICA (LHA-6) CLASS

Opportunities & Challenges

Author:
George Galdorisi & Scott Truver

'Where are the aircraft carriers?' For decades – when a crisis emerged somewhere on the globe – this was the first question a US president asked his national security and military advisors. That question is still posed today. However, increasingly it has morphed into, 'Where are the expeditionary strike groups?' The reason is clear. These naval expeditionary formations – built around a large-deck, tactical air-capable amphibious assault ship (LHA/LHD), an amphibious transport dock (LPD) and a dock landing ship (LSD) – have been employed extensively for a wide array of missions short of war. And when tensions degenerate to hostilities, these forces are the only ones likely able to provide the US military with a forcible-entry option. The *America* (LHA-6) class amphibious assault ships – increasingly forming the centrepiece of these strike groups – will therefore be right at the heart of future US naval operations.[1]

'The primary role of the nation's expeditionary forces is to land and sustain US Marines on any shore and to generate forward presence, facilitate deterrence, and project power,' Phillip Ventura, Future Amphibious Ships Manager (N953) in the Expeditionary Warfare Directorate, Office of the

The *Wasp* Amphibious Ready Group (ARG) – comprising from left to right the amphibious assault ship *Wasp* (LHD-1), the amphibious transport dock *San Antonio* (LPD-17) and the dock landing ship *Whidbey Island* (LSD-41), pictured transiting the Atlantic Ocean in July 2016. Such three-ship groups – embarking a US Marine Corps (USMC) Marine Expeditionary Unit – have formed the basis of US amphibious deployments since the 1980s. *(US Navy)*

Left: The lead *America* (LHA-6) class amphibious assault ship seen underway in the Pacific Ocean in October 2016 during operational testing and evaluation of the F-35B Lightning II strike fighter. A pair of Osprey MV-22B tilt rotors can also be seen on the flight deck. The *America* class's enhanced ability to deploy these two new aircraft types make it well placed to expand the capability and flexibility of the expeditionary strike groups and amphibious ready groups that are at the heart of current US Navy operations. *(US Navy)*

Chief of Naval Operations (OPNAV), underscored. 'The amphibious assault ship simultaneously fulfils warfighting requirements as a flagship for an embarked amphibious squadron, flag or general officer staff and as a VSTOL/STOVL aircraft carrier, with a varied complement of combat aircraft as well as a variety of unmanned aerial vehicles … And, we will continue to work on additional lethality and survivability capabilities for our expeditionary/amphibious forces.'[2]

Multi-mission capability and operational flexibility were demonstrated by the quick-response deployment of the *America* Expeditionary Strike Group (ESG) to the South China Sea in April 2020, responding to the presence of a Chinese government survey ship and its China coast guard escorts in an international maritime dispute with Malaysia. *America* operated five US Marine Corps (USMC) F-35B Lightning II Joint Strike Fighters (JSFs) alongside MV-22B Osprey tilt-rotor aircraft, and CH-53E Super Stallion helicopters. With the carrier *Theodore Roosevelt* (CVN-71) sidelined in Guam, a victim of the COVID-19 crisis, *America* was the most significant active US naval asset in the US 7th Fleet area of operations.

THE STRATEGIC CONTEXT: SHAPING A FUTURE AMPHIBIOUS FORCE

Despite their broad expeditionary attributes, the US Navy's amphibious warships have not routinely been regarded as a primary element of its front-line naval force structure for much of the post-Cold War era. In the years after 9/11 – while much of the USMC was heavily engaged in Iraq and Afghanistan and frequently not available for embarkation in amphibious ships – the navy's amphibious forces and capabilities were, at best, afterthoughts. In the new era of expanding great power competition with China and Russia, however, the USMC has steadily disengaged from land-centric conflicts and is increasingly focused on high-end naval warfare. In the words of then USMC Commandant James Amos as far back as 2012, 'The Marine Corps is returning to its amphibious roots'.[3] This is leading to an increasing interest in how the corps can most effectively partner with the navy's warships to achieve the maximum impact.

It is the renewed focus on great power rivalry that is currently driving American strategic thinking. Competition from near-peer or potentially even peer adversaries that are perceived to be seeking to shape the world to their needs and challenge the global international order has been addressed at the highest level in a series of US policy documents from the new *National Security Strategy* downwards.[4] A new, muscular approach reflected in an emphasis on high-end warfighting capacity has been a key part of the response. From a naval perspective, this has been evidenced by a series of new concepts such as Distributed Maritime Operations, Expeditionary Advanced Base Operations, and Littoral Operations in a Contested Environment. Greater coordination between the US Navy and USMC is seen as being particularly essential in this environment. For example, the navy's latest strategic document, *A Design for Maintaining Maritime Superiority 2.0*, calls for 'Deepening integration with our natural partner, the US Marine Corps'.[5] Current USMC Commandant General David Berger's *Commandant's Planning Guidance*, the Corps' primary strategy document, stipulates. 'We are a naval expeditionary force capable of deterring malign behavior and, when necessary, fighting inside our adversary's weapons-engagement-zone to facilitate sea denial in support of fleet operation and joint force horizontal escalation.'[6]

When it comes to the United States' amphibious ships – known more colloquially along the waterfront as 'Gators' – the navy is therefore not the only stakeholder. The USMC also has a vested interest in the future of these warships. Indeed, USMC Commandant General Berger has underscored the commitment to maintain and grow a robust amphibious ship inventory. During his tenure as commander of the USMC's Combat Development Command he warned, 'We need to be prepared for large-scale amphibious operations'. At the 2019 National Defense Industrial Association Expeditionary Warfare Conference he admitted, 'We might do it differently in the future, but we can't ignore it'.[7] In May 2020, Joseph Trevithick of *The Drive* noted, 'The commandant's plans focus heavily on being able to rapidly deploy Marines to a specific area, such as one island in a chain, establish an outpost, conduct operations, and then quickly move those forces to a different location in the same general operating area. The idea is that this upends

The joint US Navy/USMC Integrated Naval Force Structure Assessment (INFSA) has yet to be published but looks set to support weighting the fleet towards greater numbers of smaller vessels than hitherto, including a new light amphibious warship. This could be similar to the existing *Spearhead* (T-EPF-1) expeditionary fast transports such as *Carson City* (T-EPF-7), seen here entering Dakar in July 2019. *(US Navy)*

an opponent's response planning, reducing the vulnerability of the Marines to counter-attack, while also forcing an enemy to stretch their own assets across a wide area … amphibious ships are essential for both moving these elements around and keeping them resupplied.'[8]

AMPHIBIOUS FLEET STRUCTURE

The US Navy's amphibious fleet has – the USMC's entanglement in land engagements notwithstanding – remained relatively robust even as the fleet's overall size has shrunk from a near 600-ship high in the mid-1980s to just under 300 ships as of June 2020. Providing protected mobility for the USMC, the navy's thirty-three multi-mission amphibious warships comprise a material proportion of the total fleet. Indeed, the most recently published blueprint for the future fleet maintains and, perhaps, even increases that percentage. The 355-ship force level goal set out in the 2016 Force Structure Assessment (FSA) called for a 38-strong amphibious force including twelve amphibious assault ships, thirteen amphibious transport docks and thirteen dock landing ships.

The US Navy is currently in the course of drafting a new FSA, officially referred to as the Integrated Naval FSA (INFSA). These plans reflect the backdrop of the growing integration of US Navy and USMC planning, demonstrating a desire on the part of navy and corps leaders to 'scrap the traditional separated force structure design process and develop a single integrated naval force' or – as it is now more commonly called – 'Integrated American Naval Power'.[9] According to a Congressional Research Service (CRS) report by senior naval analyst Ronald O'Rourke, 'INFSA could result in a once-in-a-generation change in the Navy's fleet architecture'.[10]

Indeed, recent US Navy and USMC statements have emphasised the likelihood of the future amphibious fleet becoming more diversified in composition and increased in capacity by developing smaller, specialised ships as complements to the in-service family of large multi-purpose, multi-mission ships. Present thinking is to create a new and different force mix that includes not only LHA/LHD-type amphibious assault ships and LPD-type amphibious docks but also other kinds of vessel, including smaller amphibious ships. For example, at an April 2020 industry day briefing, the US Naval Sea Systems Command outlined plans to acquire as many as thirty new Light Amphibious Warships (LAWs) that would be significantly smaller and cheaper to operate than big-deck amphibious ships. The LAWs might well be important elements in how the Navy supports the USMC's still-evolving concepts for how it will conduct future expeditionary and distributed maritime operations. Moreover, in line with the USMC Commandant's Planning Guidance, the corps is moving away from the current 38-ship amphibious ship force-level goal and the associated 2.0 Marine Expeditionary Brigade (MEB) lift force-planning metric.[11]

The US Navy's amphibious assault ships provide significant potential to support evolving USMC operational concepts but come with a large price tag attached. *America* (LHA-6) – seen pictured operating with the Littoral Combat Ship *Gabrielle Giffords* (LCS-10) in the South China Sea in March 2020 – cost US$3.4bn and follow-on ships will cost more. *(US Navy)*

That said, the makeup of the US Navy-Marine Corps ESG has remained relatively consistent to date, at least since the 1980s. The centrepiece of this naval formation remains the large-deck amphibious assault ship: the LHAs and LHDs. Rounding out the group are a *San Antonio* (LPD-17) class amphibious transport dock (built in two 'flights') and a *Whidbey Island* (LSD-41) or *Harpers Ferry* (LSD-49) class dock landing ship. While it is true that ESGs frequently 'disaggregate' and go hither and yon once they are deployed to a theatre of operations, the ESG capability package the combination brings is still the unit of measure used by the US Navy and USMC when they speak in terms of a 'single integrated naval force'.

Since they form the centrepiece of the ESGs, the amphibious assault ships receive particular attention from the two sea services, as well as from Department of Defense officials, Congress and shipbuilders. This also partly reflects the fact that they are the largest and most capable ships within an ESG, providing significant potential to support evolving USMC operational concepts. This includes the medium-lift capabilities of the MV-22, the heavy-lift capabilities of the CH-53K King Stallion helicopter, and the long-range firepower with sensing and data processing capabilities inherent in the F-35B JSF The amphibious assault ships improve resilience and dispersion whilst providing the ability to operate in complex archipelagos and contested littorals without incurring unacceptable risk. Less positively, perhaps, the cost of these multi-purpose ships is also an increasingly important factor. Spending on *America*, the lead ship of LHA-6 class, was approximately US$3.4bn in

The *America* class traces its design origins back to the *Tarawa* (LHA-1) class amphibious assault ships of the 1970s, which combined improved aviation facilities with the ability to operate landing and other assault craft from a well deck. *Peleliu* (LHA-5) – pictured here in the Pacific in June 2014 – was the last of the class in service when she decommissioned in 2015, *America* (LHA-6) being her effective replacement. *(US Navy)*

The *Tarawa* class were followed into service by the *Wasp* (LHD-1) class – *Bataan* (LHD-5) is pictured here. They were essentially improved derivatives of the earlier ships with detailed improvements to their aviation facilities, well deck and general layout. *(US Navy)*

FY2015 terms and follow-on ships will cost more. And all in all, there will potentially be as many as eleven LHA-6s – two Flight 0 ships and possibly nine Flight Is – to replace the previous *Tarawa* (LHA-1) and *Wasp* (LHD-1) classes.[12]

LHA-6 CLASS BIG DECK 'GATORS': ORIGINS

Some observers have compared the three LHA-6 class ships ordered to date – *America* (LHA-6), *Tripoli* (LHA-7) and *Bougainville* (LHA-8) – to the US Navy's Second World War escort carriers (CVEs), dubbed 'Jeep carriers' or 'baby flat tops'. Smaller than the front-line attack carriers that gained capital-ship fame for winning the war in the Pacific, the CVEs were still aircraft carriers and provided air cover for amphibious landings and tactical air strikes in support of ground forces ashore. It is possible to see the *America* class in a very similar light.

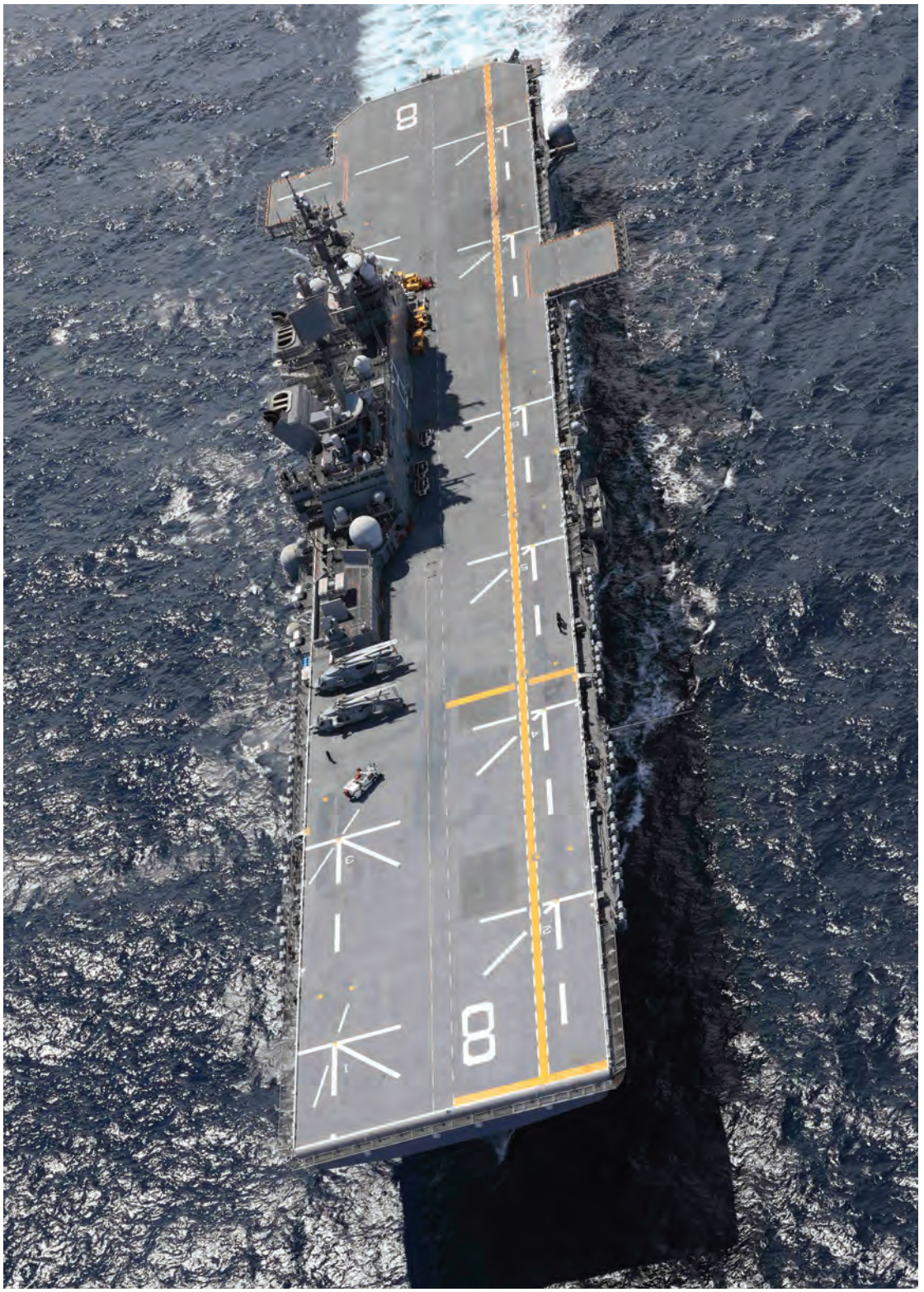
For much of the Cold War, the US Navy's big-deck amphibious ship capability resided in seven *Iwo Jima* (LPH-2) class amphibious assault ships, also referred to as landing platforms helicopter. They were the first assault ships designed and built as dedicated helicopter carriers, being capable of operating around 20 helicopters and designed to carry some 1,800 marines. The lead ship commissioned in August 1961. The *Iwo Jima* class was followed by five *Tarawa* (LHA-1) – landing helicopter assault – amphibious assault ships, which were larger and much more capable vessels. Notably, the *Tarawa* class ships were able to carry more aircraft – a mix of CH-46 Sea Knights, CH-53 Sea Stallions and AV-8B Harrier 'jump jets' – and were equipped with a well-deck capable of deploying a mix of landing craft. All the *Tarawa*s were constructed by Ingalls Shipbuilding at Pascagoula, Mississippi, now part of the Huntington Ingalls Industries (HHI) ship-building giant. Ingalls is intimately associated with the US Navy amphibious assault ship fleet, being responsible for completing every one of the LHA and LHD designated ships. The text box opposite traces their involvement in amphibious assault ship construction to the present day.

The last *Iwo Jima* class ship in service decommissioned in 2002, to be followed by the final member of the *Tarawa* class in 2015. The successor to these original big-deck amphibious ship classes is the *Wasp* (LHD-1) class landing helicopter dock. These ships are based on the *Tarawa* class but incorporate a series of modifications, notably to aircraft and landing

LHA–6 Timeline at Ingalls Shipbuilding

20 July 1966: Ingalls Shipbuilding delivers its first amphibious assault ship to the US Navy, the *Iwo Jima* class *Tripoli* (LPH-10).
14 May 1976: Ingalls delivers the first-in-class *Tarawa* (LHA-1) to the US Navy.
29 July 1989: The Ingalls-built first-in-class *Wasp* (LHD-1), its second generation of amphibious assault ship construction, is commissioned.
1 June 2007: Contract awarded for the first-in-class *America* (LHA-6); Ingalls begins preparations for building a third new amphibious assault ship class.
16 April 2009: *Makin Island* (LHD-8) is delivered to the US Navy.
17 July 2009: *America* (LHA-6) is laid down.
4 June 2012: *America* (LHA-6) is launched.
20 October 2012: *America* (LHA-6) is christened.
10 April 2014: Ingalls Shipbuilding delivers *America* (LHA-6) to the US Navy.
20 June 2014: Ingalls authenticates the keel of *Tripoli* (LHA-7)
11 October 2014: *America* (LHA-6) is commissioned.
1 May 2017: *Tripoli* (LHA-7) is launched.
16 September 2017: *Tripoli* (LHA-7) is christened.
14 March 2019: Ingalls authenticates the keel of *Bougainville* (LHA-8)
28 February 2020: *Tripoli* (LHA-7) is delivered.

Note
Based on information from Huntington Ingalls Industries and from the Naval Vessels Register. There are minor discrepancies between the two sources with respect to some dates.



Right: *Makin Island* (LHD-8) – seen during routine operations in the eastern Pacific in April 2020 – is a transitional 'bridge' design between the *Wasp* (LHD-1) and *America* (LHA-6) classes. Notably, she trialled the combined gas turbine/hybrid electric drive – essentially a form of combined diesel electric or gas (CODLOG) propulsion – adopted for the *Americas*. *(US Navy)*

craft facilities. The lead ship commissioned on 29 July 1989 and a further seven – all still in the active fleet – followed. The last of these – *Makin Island* (LHD-8) – was a transitional ship that adopted new design features such as gas turbine propulsion to form a bridge to the current *America*

class. The LHA-6 design should therefore be seen as the latest iteration of an evolutionary process going back decades to the *Tarawa* class's first inception.[13]

The LHA-6 programme's formal inception dates from July 2001. Then known as LHA(R), the design was given the green light for production early in 2006 and the lead ship was included in the navy's FY2007 construction programme. A construction contract followed in June 2007. Delivered in the spring of 2014 and commissioned in October of that year, *America* effectively replaced the last *Tarawa*, *Peleliu* (LHA-5) in the amphibious fleet.

DESIGN DESCRIPTION

America is the largest amphibious ship ever built by the United States Navy. With a full-load displacement of c. 45,000 tons, she is as large as many other countries' aircraft carriers and, indeed, can fulfil a range of aircraft carrier-type missions when appropriately configured. LHA-6 is nearly three football fields in overall length and reaches a full 20 stories in height from her keel to the top of her deckhouse. The assault ship's flight deck has an area greater than two acres. Full design details are provided in the particulars listed in Table 3.3.1.

Mission: The *America* class ships are essentially designed to perform similar missions to predecessor amphibious assault ships; but with significantly more capability and capacity, and with substantially newer technology. More specifically, the class is designed to land and sustain US Marines on any shore and to support forward presence, power projection and deterrence roles. The ships are able to provide flagship facilities for amphibious and other operations and can operate as substitute aircraft carriers when an enhanced air group of F-35B strike fighters is embarked. They are capable of conducting

Table 3.1.1.

AMERICA (LHA-6) PRINCIPAL PARTICULARS

Building Information:	
Keel Laid:	17 July 2009[1] **Christened:** 20 October 2012[1] **Delivered:** 10 April 2014
Builders:	Ingalls Shipbuilding division of Huntington Ingalls Industries at its facility at Pascagoula, Mississippi.
Dimensions:	
Displacement:	c. 45,000 tons full load displacement.
Overall Hull Dimensions:	260.7m x 36.0m x 8.6m. Waterline beam is 32.3m.
Flight Deck Dimensions:	249.6m x 36.0m. 2 x deck edge elevators. 9 x landing spots for aircraft of up to MV-22 Osprey size.
Weapons Systems:	
Aircraft:	A typical air group comprises 12 x MV-22 Osprey, 4 x CH-53K King Stallion, 7 x AH-1Z/UH-1Y Viper/Venom & 2 x MH-60S Knighthawk rotorcraft plus 6 x F35B Lightning II STOVL fast jets.
Missiles:	2 x Mk 29 octuple launchers for Sea Sparrow surface-to-air missiles. 2 x RAM Mk 49 launchers for RIM-116 rolling airframe missiles.
Guns:	2 x Mk 15 20mm Phalanx CIWS. 3 x Mk 38 Mod 2 Mounts for 25mm Bushmaster cannon. Machine guns.
Countermeasures:	SLQ-32B electronic warfare suite. Mk 53 Nulka and SRBOC decoy launchers. SLQ-25C Nixie towed decoy.
Principal Sensors:	1 x SPS-48E 3D air-search radar. 1 x SPS-49A 2D air-search radar. 1 x SPQ-9B horizon-search radar. Surface-search, navigation and air traffic control radars.
Combat System:	Ship Self Defense System (SSDS) Mk2 Mod 4B. Cooperative Engagement Capability (CEC). Integrated communications include links 4A, 11 and 16.
Propulsion Systems:	
Machinery:	Hybrid Electric Drive (HED). 2 x GE LM2500+ gas turbines rated at 52MW total. 2 x Converteam electric motors rated at 7.5MW total draw power from 6 x 4MW Colt-Pielstick PA6B diesel generators. Maximum 70,000shp on direct gas turbine drive or 10,000shp on electric motors through two shafts.
Speed:	Designed maximum sustained speed is 22.3 knots.
Other Details:	
Complement:	Crew is c. 1,060 including 65 officers. Accommodation is provided for 1,204 crew members including 102 officers.
Military Lift:	Can accommodate up to 1,687 troops plus a further 184 in surge conditions. Significant vehicle and cargo carrying capacity.
Class:	Flight 0: *America* (LHA-6); *Tripoli* (LHA-7).

Notes:

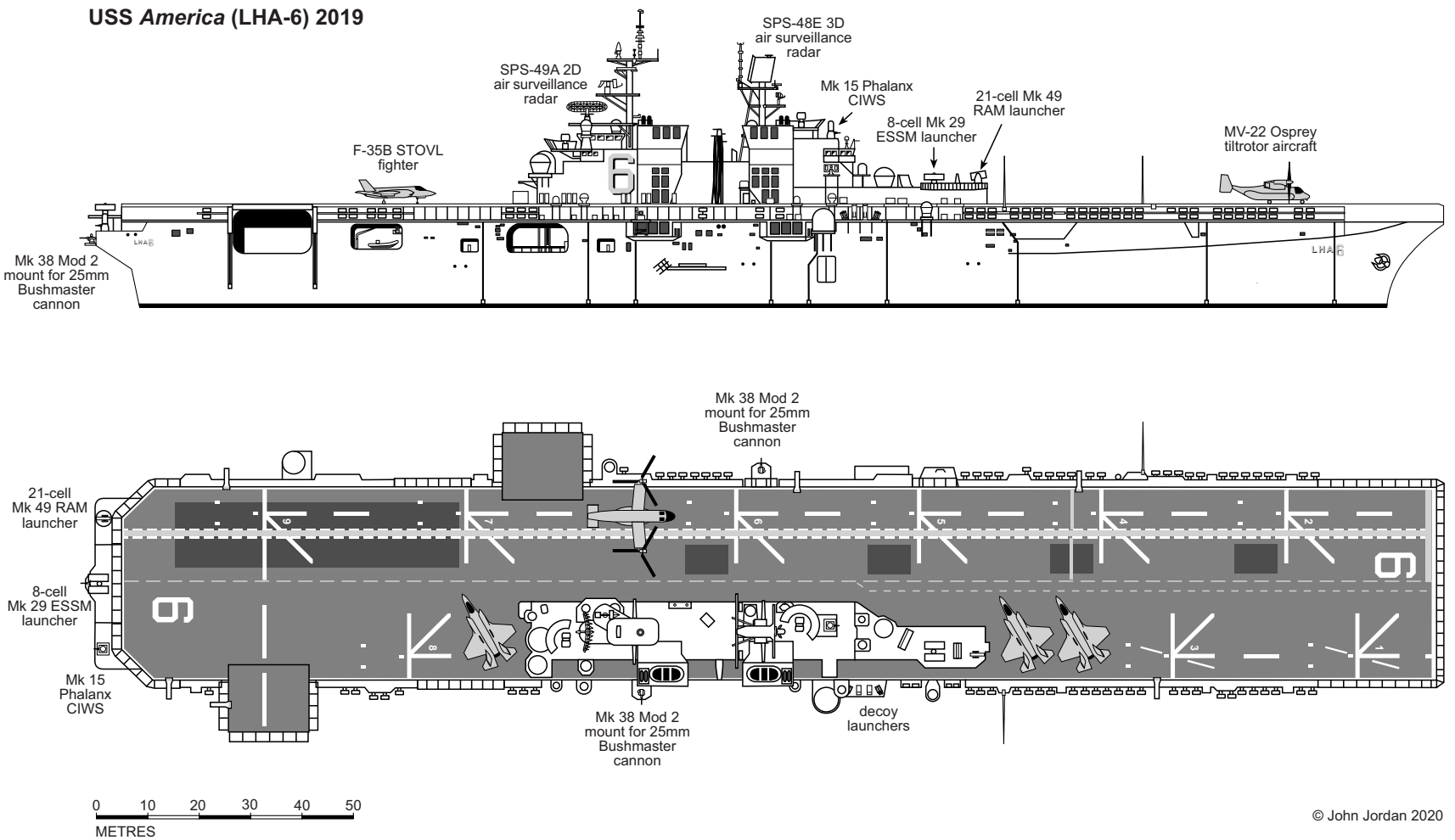
1. Ceremonial dates. Actual keel laying took place on 27 April 2009 according to the Naval Vessels Register, with physical launch on 6 June 2012.

non-combatant evacuation operations and other crisis response missions.

America was conceived at a time when expanding anti-access/area denial (A2/AD) capabilities of potential adversaries had achieved the potential to stop a waterborne assault dead in its tracks. However, amphibious assault ships have the ability to operate at a stand-off distance outside the range of many adversary anti-access systems, using their aviation capabilities to keep marines away from the mines and other threats awaiting a traditional beach landing. This led to a conscious decision to prioritise aviation facilities in the two *America* Flight 0 ships, which were not equipped with a well deck for landing craft. Instead, hangar volume was increased to carry a greater number of fixed wing and rotary aircraft, as well as additional aviation-specific equipment, material, and more JP-5 aviation fuel. Although removal of the well deck made space for only two or three more aircraft, it did provide around 40 percent more hangar space, two additional high bay areas and capacity for heavy lift equipment.[14]

The LHA-6 design is provided with accommodation for a ship's complement of c. 1,200 personnel, including 102 officers. Additional berthing is available for nearly 1,700 marines plus almost 200 more in overload conditions. This represents the majority of that required for the Marine Expeditionary Units (MEUs) that embark in the ESGs. Each ship also has around 12,000ft^2 of vehicle stowage and capacity for a substantial volume of cargo and ammunition. The storage areas and magazines are serviced by six 12,000lb (c. 5.5 ton) cargo elevators. Medical facilities include two operating theatres, four dental treatment rooms and ward space for twenty-six intensive care beds.

USS *America* (LHA-6) 2019


SPS-48E 3D air surveillance radar
SPS-49A 2D air surveillance radar
Mk 15 Phalanx CIWS
21-cell Mk 49 RAM launcher
8-cell Mk 29 ESSM launcher
F-35B STOVL fighter
MV-22 Osprey tiltrotor aircraft
Mk 38 Mod 2 mount for 25mm Bushmaster cannon
Mk 38 Mod 2 mount for 25mm Bushmaster cannon
21-cell Mk 49 RAM launcher
8-cell Mk 29 ESSM launcher
Mk 15 Phalanx CIWS
Mk 38 Mod 2 mount for 25mm Bushmaster cannon
decoy launchers
0 10 20 30 40 50
METRES

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Growing anti-access/area denial (A2/AD) threats resulted in a conscious decision to prioritise the *America* class's aviation facilities – designed around new types such as the F-35B Lightning II STOVL variant and MV-22 Osprey – over 'shorter-legged' amphibious landing craft. Both aircraft types are evident in this February 2020 view of LHA-6. *(US Navy)*

A picture of *America*'s hangar in 2017 showing one of the AV-8B Harriers embarked for her maiden operational deployment. The hangar is optimised for the replacement F-35B Lightning II, which has a larger physical and maintenance footprint. *(US Navy)*

Aviation Facilities: The exact make-up of an *America* class air group will inevitably vary according to the mission and threat. However, for amphibious operations with an embarked MEU, the notional air group was set at twelve MV-22 Ospreys, six F-35B STOVL Lightning II strike fighters, four CH-53K King Stallion heavy transport helicopters, seven AH-1Z/UH-1Y Viper attack/Venom utility helicopters and two US Navy MH-60S Knighthawks for air-sea search and rescue (SAR). An alternative air group under a so-called 'Lightning Carrier' configuration could see a fixed wing complement of twenty F-35Bs supported by two MH90S helicopters.

The LHA-6 flight deck is laid out with nine landing spots for MV-22 and/or CH-53 rotorcraft. There are six refuelling locations on the flight deck and two additional points in the hangar, which is serviced by two 70,000lb (35-ton) capacity lifts. The US Navy continues to resist the ski-jump configuration used by other navies operating STOVL carriers, largely because it would see the loss of at least one landing spot. The comparatively long flight deck run provides some compensation. A number of areas of the flight deck have been treated with thermal-resistant coatings to facilitate F-35B operations.

Structure and Propulsion: LHA-6 has an overall length of 855ft (261m) and a beam of 106ft (32m) at the waterline, the latter being set by the limits of the Panama Canal locks (i.e. the Panamax limit) before the waterway's recent upgrades. Construction – taking approximately five years in total – consisted of 216 structural units. These required 170 erection lifts, including grand blocks, plus two lifts to set the deckhouse on board. The latter comprised the main deckhouse followed by the smaller forward section. Assembly of the blocks took place on land, starting with the ship's midsection. The ship was then moved to dry dock for launch by means of so-called translation cars.

LHA-6 was constructed to US Navy Design Standards and has an intended service life of some 40 years. Her hull comprises a mix of HSS and HY-80 steel, whilst her flight deck uses the same HSLA-100 high-strength, low-alloy steel found in US Navy aircraft carriers. The island structure is largely fabricated out of aluminium. Survivability is in line with the US Navy's Level 2 (moderate) requirements and includes fragmentation protection in appropriate areas. *America* class ships have been reported as incorporating 1,000 miles of electrical

The *America* class ships are provided with a powerful array of medium and close-range weapon systems controlled by the Ship Self-Defense System (SSDS). This picture shows a test firing of a RIM-116 RAM missile from the ship's forward Mk 49 launcher. *(US Navy)*

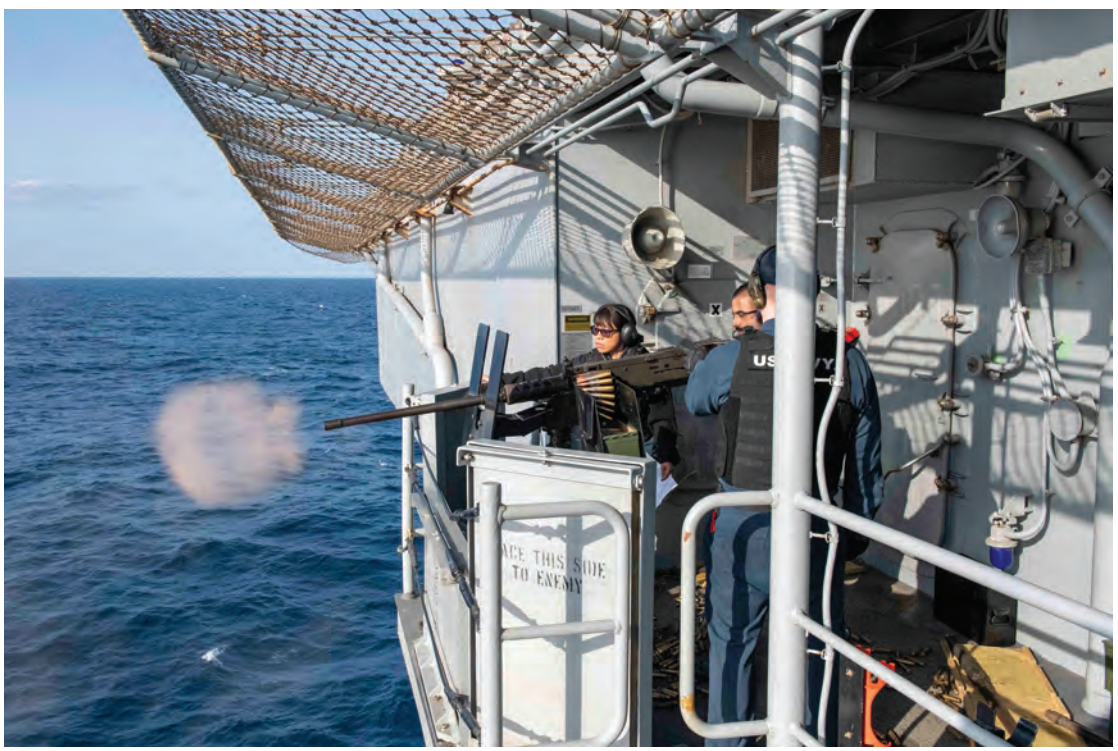
cable, 431,000ft of pipework and enough hull installation to cover 40 acres.

America is engineered with a hybrid-electric propulsion system derived from the plant installed on *Makin Island*. LHA-6 is propelled by two GE LM2500+ marine gas turbine engines, providing a total of 70,000 shp (52MW), as well as by two 5,000 shp (3.7MW) induction-type auxiliary propulsion motors that are powered from the ship's electrical grid. Six generator sets supplied by Fairbanks Morse and incorporating 12-cylinder Colt-Pielstick PA6B diesels provide the necessary electrical capacity. *America* can use direct drive from the gas turbines for high speeds – sustained maximum speed is in excess of 22 knots – and the electrical auxiliary propulsion system (APS) for slower but more fuel-efficient operation.

Defensive Systems and Sensors: The core of the LHA-6's defensive capabilities is provided by Raytheon's Ship Self-Defense System (SSDS), the combat management system installed in many of the US Navy's non-Aegis equipped combatants. *America* uses the SSDS Mark 2 Mod. 4B variant. As with other modern combat management systems, SSDS links the picture provided by a ship's sensors with its weapons and countermeasures to provide the optimum response to a potential threat. It is also integrated with cooperative engagement capability. SSDS is controlled from a state-of-the-art command and control complex.

Core defensive armament comprises two Mk 29 octuple launchers for the RIM-162 Evolved Sea Sparrow Missile (ESSM), two RAM Mk 49, 21-round launchers for the RIM-116 Rolling Airframe Missile (RAM) and two Phalanx close-in weapons systems. These are supplemented by three Mk 38 Mod 2 mounts for single 25mm Bushmaster cannon and by heavy machine guns. Countermeasures include the AN/SLQ-32B electronic countermeasures suite, the Nulka Mk 53 decoy system and the AN/SLQ-25C Nixie towed torpedo decoy.

Key surveillance sensors encompass an AN/SPS-48E long range 3D air-search radar, an AN/SPS-49A long-range 2D air-search array and an AN/SQ-9B radar for lower-level horizon search.



A test firing of a .50-calibre machine gun on *America* (LHA-6) during a live fire exercise. The ship is fitted with numerous light weapons positions for self-defence against asymmetric threats. *(US Navy)*

America's Flight 0 sister *Tripoli* (LHA-7) incorporates only few differences from the lead ship. This picture shows her in Ingalls Shipbuilding's floating dock on 1 May 2017 in the course of being floated out. *(Huntington Ingalls Industries)*

The third *America* class amphibious assault ship, *Bougainville* (LHA-8), will be constructed to a revised Flight 1 design that involves reversion to a well deck. This will reduce hangar space and the island structure has been redesigned to allow for more maintenance space on her flight deck. However, the new Flight's main disadvantage is the loss of fuel capacity caused by the need to incorporate ballasting arrangements. *(Huntington Ingalls Industries)*

There are also additional surface-search, navigation and air traffic control arrays. The integrated communications suite provides a full spectrum of communications systems and supports NATO Link 4A, 11 and 16 compatibility.

Flight 1 Design: *America*'s Flight 0 sister *Tripoli* incorporates only few differences from the lead ship, largely relating to incorporation of a new firefighting system and updates to the radar and the command, control, communications, computers and intelligence systems. However, the third member of the class – *Bougainville* – is being built to a revised Flight 1 specification. Whilst described as maintaining the improved aviation capabilities provided by LHA-6 and LHA-7, the Flight 1 design is notable in reverting to use of a well deck.

The decision to revert to the more traditional well deck configuration has not been without its critics. The redesign has involved a number of trade-offs. On the plus side, the Flight I design's restored ability to embark traditional and air-cushioned landing craft will also be accompanied by an increased vehicle-carrying capacity. However, there will be a modest reduction in accommodation for embarked marines, a slight fall in medical intensive care capacity and a more material decline in aviation support facilities in spite of efforts to increase flight deck space by use of a smaller island design and adding a forward starboard side sponson. However, the most significant downside is the marked reduction in fuel capacity that will arise from restoring the ballasting arrangements required for well deck operation. This may account for reports that the Flight 1 design will be equipped with less powerful, standard LM2500 gas turbines generating a maximum 59,000 shp (44MW).[15] Maximum sustained speed will fall to c. 21 knots in consequence.

In addition to structural changes, *Bougainville* will take advantage of ongoing improvements to US Navy sensors and defensive systems. An important improvement will be substitution of Raytheon's AN/SPY-6(V)2 Enterprise Air Surveillance Radar (EASR) in place of the legacy AN/SPS-48E. Navigation and air traffic arrays will be amongst other systems benefitting from similar upgrades.

OPERATIONAL EXPERIENCE

Following completion of acceptance trials and delivery to the US Navy in the first half of 2014, *America* departed her building yard at Pascagoula on

11 July of that year. She subsequently passed from the Atlantic to the Pacific Oceans by means of the Magellan Strait before arriving at her new homeport in San Diego, CA on 15 September. She was commissioned at San Francisco on 11 October 2014 as part of Fleet Week activities.

Following completion of a ten-month so-called 'post-shakedown availability' defect rectification period – including flight deck and other modifications to facilitate F-35B operation – *America* returned to sea towards the end of March 2016. She subsequently participated in the RIMPAC 2016 exercises. In the autumn, in a harbinger of her future role, she embarked F-35B Lightning II STOVL aircraft for developmental carrier suitability and integration trials. Her first operational deployment commenced in July 2017 when she departed San Diego at the head of the *America* Amphibious Ready Group with the 15th Marine Expeditionary Unit embarked. The seven month deployment took her to the Pacific, Indian Ocean and Middle East, returning to San Diego in early February 2018.

In the second half of 2019, *America* participated in further qualification operations with F-35B aircraft. These included embarkation of as many as thirteen F-35Bs of Marine Fighter Attack Squadron 122 (VMFA-122), the 'Flying Leathernecks', in what has been reported as a trial of the 'Lightning Carrier' concept. The trials assessed the ship's ability to support high sortie rates whilst maintaining aircraft readiness, as well as testing ship communications and multi-ship control. The assessment was very successful and provided valuable lessons that will be incorporated in future tests and evaluations. These will increase the quantity of embarked aircraft to the twenty-strong air group envisaged in the carrier role.

America became a Forward Deployed Naval Force (FDNF) asset under the US Navy's Seventh Fleet when she conducted a homeport shift from San Diego to Sasebo, Japan in December 2019. Here she replaced *Wasp.* Her first patrol deployment – with the 31st MEU embarked – commenced in spring 2020. The ship's lack of a well deck meant that, in comparison to *Wasp*, fewer landing craft – three fewer landing craft air cushion (LCACs) or two fewer utility landing craft (LCUs) – could be carried in the ESG. The 31st MEU developed an optimal configuration for their equipment load-out to best operate in these changed circumstances and reported few issues handling the unit's equipment. *America's*

America (LHA-6) underway in the Gulf of Aden in October 2017 during the course of her first operational deployment. This is likely to be the only occasion on which the AV-8B Harrier will be embarked operationally in the class. *(US Navy)*

America pictured departing San Diego in November 2019 to join the navy's forward-deployed forces in Sasebo, Japan, where she is currently serving as the flagship for Expeditionary Strike Group 7. *(US Navy)*

increased aviation capacity – including two more MV-22B Ospreys than *Wasp* typically deployed – added to the overall medium-lift airlift capability, compensating for the loss of lift by surface landing craft.

CHALLENGES AND OPPORTUNITIES

In spite of the capabilities that the LHA-6 design provides, there are clear challenges to future amphibious assault ship procurement. The delayed publication of the INFSA and the likely development of a new amphibious force construct that moves away from the previous 38-ship force goal in favour of a flotilla that is more numerous but includes cheaper ship types has spawned considerable uncertainty. Moreover, it is clear that the navy's shipbuilding budget is under enormous stress. Notably, acquisition of the new *Columbia* (SSBN-826) class strategic submarines is the navy's number-one procurement priority. But they are enormously expensive, squeezing funding for everything else.

It is also possible that the potential inherent in the *America* class has ruffled some US Navy feathers. The navy is sometimes seen as having three primary warfighting 'constituencies' – surface warships, submarines and naval aviation – that frequently compete for *primus inter pares* priority and scarce funding. The additional aviation capabilities brought to the table by the LHA-6 design – particularly the USMC F-35B-based 'Lightning Carrier' concept endorsed by Commandant Berger and others – can be regarded as disrupting this relationship. In particular, these capabilities could be seen as a direct 'threat' to the mission – power projection – that the mainstream naval aviation community and their large, fixed-wing carriers have owned since the Second World War.

This unease could also explain some of the uncertainty over the desirability – or not – of a well deck in future class members. Whilst shifting the class closer to the LHA's traditional role, the loss of aviation capability has been questioned by many. Hostile sea-to-shore landings are now unlikely to be a priority in the face of the strong AA/A2 capabilities provided by precision-guided weapons; an amphibious operation against a defended beach in such circumstances would likely be an exceptionally risky undertaking. Whilst such operations might not be entirely off the table, the benefits of going around an obstacle by means of helicopter assault rather than over and through it are significant.

America will soon be followed into operational service by *Tripoli* (LHA-7), pictured here on builders trials in the Gulf of Mexico in July 2019. Delivered on 28 February 2020, she should be commissioned by the end of 2020, possibly after completing her long delivery voyage to the Pacific. To date, she is the final Flight 0 variant of the LHA-6 class. *(Huntington Ingalls Industries)*

These arguments clearly support more ships like the Flight 0 LHAs.[16]

It is also noteworthy that the USMC's latest strategic document, *Force Design 2030*, reflects the thinking that the corps must move on from outdated concepts.[17] The document is a clear signpost of Commandant Berger's intent to make the USMC leaner and meaner, eliminating tanks, artillery and other heavy assets to create a more agile and rapidly deployable force. Of course, this is the very equipment that would be carried ashore by well deck-equipped amphibious ships. However, Commandant Berger's desire for a more numerous, distributed force through procurement of cheaper designs such as the LAW does not mean that a return to the Flight 0 LHA design is necessarily seen as the way forward.

The *America* class's potential as a 'Lightning Carrier' has ruffled some feathers in the US Navy establishment as the concept could challenge the traditional dominance of the navy's large strike carriers in the power-projection role. Here *America* is seen operating in company with the nuclear-powered carrier *Theodore Roosevelt* (CVN-71) early in 2020. *(US Navy)*

TAKING ADVANTAGE OF THE *FORD* EXPERIENCE

Given the uncertainties resulting from the unfinished INFSA process and broader backdrop of strategic change in both the US Navy and USMC, it is easy to see how the US Congress could decide to adopt a 'wait and see' attitude before supporting additional amphibious assault ship procurement. Interestingly, however, this has been far from the case.

The second half of 2020 should see commissioning of *Tripoli*, the second and – to date – final Flight 0 variant of the LHA-6 class. Authorised four years later than *America* under the FY2011 navy construction programme, she has also taken somewhat longer to deliver. The next amphibious assault ship – and first Flight 1 LHA-6 variant – *Bougainville* was authorised under the FY2017 programme, some six years after *Tripoli* was approved. US Navy plans then envisaged a seven-year gap under the second Flight 2 unit, LHA-9, was procured in the course of FY2024. This seems to indicate that the US Navy has been intent on stretching out the *America* class programme in the face of its various funding challenges.

An aerial view of HII's Ingalls Shipbuilding division in Pascagoula, Mississippi, taken in May 2019. *Tripoli* (LHA-7) can be seen completing fitting-out in the foreground. The facility is currently constructing *Bougainville* (LHA-8) and a debate is underway about accelerating an order for the next member of the class, LHA-9, to sustain a 'hot' production line. *(Huntington Ingalls Industries)*

Congress has taken a different view. Acceleration of LHA-9 would sustain a 'hot' production line and a supplier base of 457 companies in 39 states, generating a raft of cost efficiencies. As CRS's O'Rourke has pointed out, Congress has encouraged the navy to procure LHA-9 earlier than previously intended to achieve better production learning curve benefits whilst shifting from production of LHA-8 to LHA-9, the first two Flight 1 warships of the class with well decks. More specifically, this has seen Congress provide US$1bn of unrequested funding in FY2019 and FY2020 to support acquisition of the ship and specifically authorise her procurement in the FY2020 National

America pictured with thirteen F-35B Lightning II strike fighters embarked in October 2019 during trials as a 'Lightning Carrier'. Development of this concept could be accelerated by the US Navy's efforts to develop a more distributed force structure. *(US Navy)*

Defense Authorization Act. However, the US Department of Defense has seemed reluctant to take advantage of Congress's largesse, presenting LHA-9 as a ship projected for procurement in FY2023 (i.e. a one year advance on its own previous plans) in its FY2021 budget submission.[18]

One possible way to square the circle in the longer term would be to take advantage of the '*Ford* experience'. Innovative thinking in 2018–19 resulted in signature of a carrier block-buy contract with HII's Newport News Shipbuilding in January 2019 that reduced the estimated cost of building the next two *Ford* (CVN-78) class carriers – *Enterprise* (CVN-80) and *Doris Miller* (CVN-81) – from U$28bn to US$24bn. Unsurprisingly, there has been interest in applying the same method to purchasing not only future large-deck amphibious assault ships but also the Flight II *San Antonio* class amphibious transport docks. As the same shipbuilder – HII – constructs both types, such an approach could leverage cost efficiencies with respect to design practices, engineering and equipment procurement common to both classes.[19]

In October 2019 the US Navy sent a report to Congress on a proposed LHA two-ship block buy, predicting savings as great as 6.31 percent (US$552M), compared to two traditional one-ship contracts. NAVSEA noted the block-buy contract savings resulted from stabilising the industrial and supplier base with a predictable workload, an optimised economic order of quantity, reduced overhead rates, production efficiencies, optimal build cycles, maximum learning impacts, and minimised inflation/escalation impacts.

In the more immediate future, it appears that Congress is making progress in persuading the navy to adopt its thinking with respect to LHA-9. In the second quarter of 2020 the US Navy awarded HII contracts totalling over US$330m for procuring long-lead-time material for this fourth member of

America conducting flying operations during the 2016 RIMPAC exercises. Whilst the class's future procurement and use remain work in progress, the design offers sufficient flexibility to remain central to any likely new fleet structure on which the joint commitment to field 'Integrated American Naval Power' will depend. *(US Navy)*

the *America* class.

LOOKING TO THE FUTURE

In the face of many uncertainties, the US Congress has articulated a strong commitment to build out the *America* class programme. These capable ships remain well-suited to form the centrepieces of US Navy-Marine Corps expeditionary strike groups for 40 years, if not beyond. And notwithstanding the stated desire to diversify capabilities through development of new smaller and cheaper ship types such as the proposed light amphibious warship. The design is sufficiently flexible to remain central to any likely new fleet structure on which the joint commitment to field 'Integrated American Naval Power' will depend.

In the final analysis, the sea change that is currently impacting US Naval thinking means that the crystal ball through which to examine the future path that LHA-6 design, procurement and deployment is likely to remain murky for a while yet. Much will inevitably depend on the result of the US presidential election scheduled towards the end of 2020. Issues such as total class numbers, the well deck configuration and the potential for 'Lightning Carrier' concept all remain work in progress. However, perhaps the most important question yet to be answered is which member of the class will show up for the next crisis, when the president asks, 'Where are America's "Gators"?'

Notes

1. US Navy amphibious ships sometimes deploy operationally as expeditionary strike groups (ESGs) and sometimes as amphibious ready groups (ARGs). Both formations have a three-ship core comprising an LHA/LHD; LPD and LSD and embark the personnel, equipment and aircraft of a Marine Expeditionary Unit (MEU). However, an ESG is reinforced with other assets such as surface warships and/or submarines to increase its potency. In this chapter, the term ESG is used to refer to both group structures.

2. Mr Ventura provided this explanation in a response dated 20 May 2020 to a series of questions asked by *Seaforth World Naval Review*. The authors are grateful to Mr Ventura for his assistance and information whilst preparing this article.

3. See Otto Kreisher, 'U.S. Marine Corps Is Getting Back to Its Amphibious Roots' posted to the *Defense Media Network* site – www.defensemedianetwork.com – on 8 November 2012.

4. *The National Defense Strategy* (Washington DC: Department of Defense, January 2018).

5. John M. Richardson, *A Design for Maintaining Maritime Superiority 2.0* (Washington DC: Department of the Navy, December 2018), p.14.

6. David H. Berger, *38th Commandant's Planning Guidance* (Washington DC: USMC, 2019), p.23. For additional discussion see the authors' 'Accelerating the Renaissance of the U.S. Navy's Amphibious Assault Forces' posted to the *Center for International Maritime Security* site – cimsec.org – on 9 May 2019.

7. David H. Berger, keynote remarks, National Defense Industrial Association Expeditionary Warfare Conference, Annapolis MD, 16–18 October 2018.

8. Joseph Trevithick, 'Navy Wants to Buy 30 New Light Amphibious Warships to Support Radical Shift in Marine Ops' posted to *The Drive* – www.thedrive.com – on 5 May 2020.

9. For further discussion on the implications of this approach, see Otto Kreisher, 'Navy, Marines Single Integrated Naval Force Means Sweeping Changes,' posted to the Navy League of the United States *Seapower* site – seapowermagazine.org – on 5 December 2019.

10. See Ronald O' Rourke, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress RL32665* (Washington DC: Congressional Research Service, 2020), Summary.

11. The current 38-ship amphibious ship force-level goal is intended to meet a requirement for having enough amphibious shipping to lift the assault echelons of two Marine Expeditionary Brigades (MEBs), a requirement known as the 2.0 MEB lift requirement. This lift requirement was first set in 2006 and is starting to lose relevance as the prospects of a major amphibious beach assault fade.

12. This calculation is based on the 2016 FSA requirement for twelve LHA/LHD type ships. The twelfth ship under this arithmetic is *Makin Island* (LHD-8), which represents a 'bridge' between the *Wasp* and *America* designs.

13. See Edward Feege and Scott C. Truver, 'USS *Makin Island* (LHD-8): It's What's Inside That Counts,' *Seaforth World Naval Review* (Barnsley: Seaforth Publishing, 2011), pp.128–47.

14. Some of the aviation platforms embarked in the *America* class, specifically the MV-22 Osprey and the Joint Strike Fighter, have a larger footprint for maintenance than previous aircraft.

15. The JP-5 fuel used by the ship's gas turbines is also that used by the embarked aircraft. There is therefore a trade-off between ship endurance and the ability to sustain air operations.

16. A good case for the approach taken in the Flight 0 *America* class ships was provided by Lieutenant Daniel Stefanus, USN in an article entitled 'From Wells to Wings' published in *Proceedings* – December 2017 (Annapolis MD: United States Naval Institute, 2017). He states, 'Today's ARG-MEU has become antiquated and inefficient—overpowered for a land-based skirmish and underpowered in shaping and striking power … When examining the arc of contemporary warfare, it is apparent that hostile beachheads are low on the list of probable battlefields …Much ire greeted the decision to commission the LHA Flight 0 ships, the USS *America* (LHA-6) and USS *Tripoli* (LHA-7), without well decks. While the reaction was understandable given the history of Navy/Marine Corps wet-well operations, the warfare of the past is the greatest enemy of future warfighters … No ARG-MEU has used its well decks against an opposed beachhead in the past decade. Sacrificing aviation-focused capabilities for a miniature well deck in the *Bougainville* enables the mission creep and compromise that the Marine Corps and Navy have been attempting to fight for years. Instead of making the LHAs Swiss-army knives, the Navy must let them focus on their core mission as expeditionary, Marine-oriented aviation platforms and leave secondary missions to the LPDs and LSDs.'

17. David H. Berger, *Force Design 2030* (Washington DC: USMC, 2020).

18. For further discussion see Ronald O'Rourke, *Navy LPD-17 Flight II and LHA Amphibious Ship Programs: Background and Issues for Congress R43453* (Washington, DC: Congressional Research Service, 2020). An issue of considerable ire for some members of Congress was an attempt to re-allocate funds intended for LHA-9 procurement to build President Trump's Mexican border wall.

19. Ingalls also builds US Navy *Arleigh Burke* (DDG-51) class destroyers and the US Coast Guard's 'Legend' (WMSL-750) national security cutters (NSCs). The latter are designed for transoceanic operations in important world regions, contributing to US maritime – as well as naval – security.

SOVEREIGNTY
16

3.2 SIGNIFICANT SHIPS

Author:
Guy Toremans

INDEPENDENCE CLASS LMVs

Singapore's 'Next Generation Warships'

Situated at the end of the Malaysian peninsula, and with the Indonesian archipelago stretched around it, lies the strategically located city-state of Singapore. With an area of little more than 700km^2 – including its numerous small islets – Singapore sits astride two of the world's most important and busiest shipping lanes; the Strait of Malacca and the Singapore Strait. As the city-state largely relies upon the maritime nature of its economy, the Republic of Singapore Navy (RSN) plays a prominent role in ensuring its security of its infrastructure, territorial waters and sea lines of communication (SLOC) to safeguard an unbroken supply of daily necessities.

The RSN has come a long way from its humble beginnings some 53 years ago. Starting with just two small seaworthy ships, the sea service has steadily improved and increased its capabilities. Today the RSN is undoubtedly one of the best trained and equipped navies in the region. To meet the demands of modern warfare and the increase in asymmetric threats arising from an ever-changing security environment, the RSN places particular emphasis on technology to tailor its platforms for maximum flexibility and to support missions across a broad spectrum of operations.[1]

LITTORAL MISSION VESSEL GENESIS

The RSN's littoral mission vessel (LMV) programme had its genesis towards the end of the first decade of the new millennium when the navy

The lead *Independence* class littoral mission vessel pictured in 2017. In line with the RSN's priorities, the class utilises an array of innovative and smart technologies to provide maximum multi-mission flexibility. *(Guy Toremans)*

Left: A photograph of the second *Independence* class littoral mission vessel, *Sovereignty*, taken in May 2017, several months before she was formally commissioned. Replacing the previous *Fearless* class patrol vessels, the new littoral mission vessels are designed to undertake a broad range of missions in Singapore's offshore waters. *(Guy Toremans)*

started to consider replacements for its existing c. 500-ton *Fearless* class patrol vessels, which had entered service between 1996 and 1998.[2] A joint project team led by the RSN and Singapore's Defence Science & Technology Agency (DSTA) was tasked with developing a new type of multi-role vessel capable of undertaking a wide range of maritime security duties ranging from high end warfighting to a spectrum of military operations other than war in Singapore's offshore waters.[3] This project became known as the littoral mission vessel.

The LMV's initial design phase lasted over three years. Beyond the requirement to develop a platform optimised to carry out a wide range of missions, a major design imperative was to reduce crewing levels in the face of a growing demographic challenge impacting Singapore's armed forces. The ultimate objective was to man the new platforms with a core crew of around twenty-five but to have accommodation to embark up to thirty-five additional personnel dependant on the specific mission tasking. The project team looked into advanced sense-making and decision support functions to increase the level of automation in support of this target. Part of this process eventually saw DSTA construct a System-of-System Integration Laboratory (SoSIL) to mimic the working of the integrated command centre (ICC) being designed for the class. Prospective crewmembers were placed in various at-sea scenarios in the laboratory, with the team at DSTA using this to study ICC workflows and how each crew member responded to a range of simulated operational scenarios.[4]

A major step forward in the LMV's realisation was achieved on 30 January 2013, when Singapore's Ministry of Defence awarded local company Singapore Technologies Engineering Ltd (STE) the contract for the design and construction of eight new littoral mission vessels. Under the agreement, the DSTA was the overall programme manager and systems integrator for the project, with STE's ST Marine subsidiary building the vessels and carrying

Table 3.2.1.

INDEPENDENCE PRINCIPAL PARTICULARS

Building Information:[1]				
Laid Down:	11 September 2014	**Launched:** 3 July 2015	**Commissioned:**	5 May 2017
Builders:	ST Marine at their Benoi Shipyard, Singapore			
Dimensions:				
Displacement:	c. 1,250 tons			
Hull Dimensions:	80m x 12m x 3m			
Equipment:				
Guns:	1 x 76mm OTO 76/62 gun. 1 x 25mm Rafale remote weapons station, 2 x OTO Hitrole 12.7mm remote weapons stations.			
Missiles:	12 x VLS cells for Mica M surface-to-air missiles.			
Other:	Mission bay for four 20ft standard containers.			
	Stern launching slip for two RHIBS or USVs. Adaptable for additional weapons systems & sensors in standard containers.			
	Non-lethal systems including 2 x LRAD & water cannons.			
Countermeasures:	Elta Elrisa ESM and Rafael ECM.			
	2 x STE chaff launchers			
Aircraft:	Flight deck only for one medium-sized helicopter or UAVs.[2]			
Principal Sensors:	Thales NS 100 surveillance radar. Integrated IFF. Navigation radar.			
Combat System:	STE integrated CMS with Sagem gun fire-control system. Integrated communications suite.			
Propulsion Systems:				
Machinery:	CODAD. 4 x MTU 20V 4000 M93L diesels each rated at 4.3MW provide a total of 17.2MW through two shafts.			
Speed:	27 knots plus. Official endurance is 3,500 nautical miles at cruising speed.			
Other Details:				
Complement:	23 including 5 officers. Bunks for a total of 61 personnel.			
Class:	*Independence* (15), *Sovereignty* (16), *Unity* (17), *Justice* (18), *Indomitable* (19), *Fortitude* (20), *Dauntless* (21) & *Fearless* (22).			

Notes:

1. A first steel-cutting ceremony was held in June 2014. Delivery took place in May 2016

2. Only *Independence*, *Fortitude*, *Dauntless* and *Fearless* are currently equipped for helicopter operation.

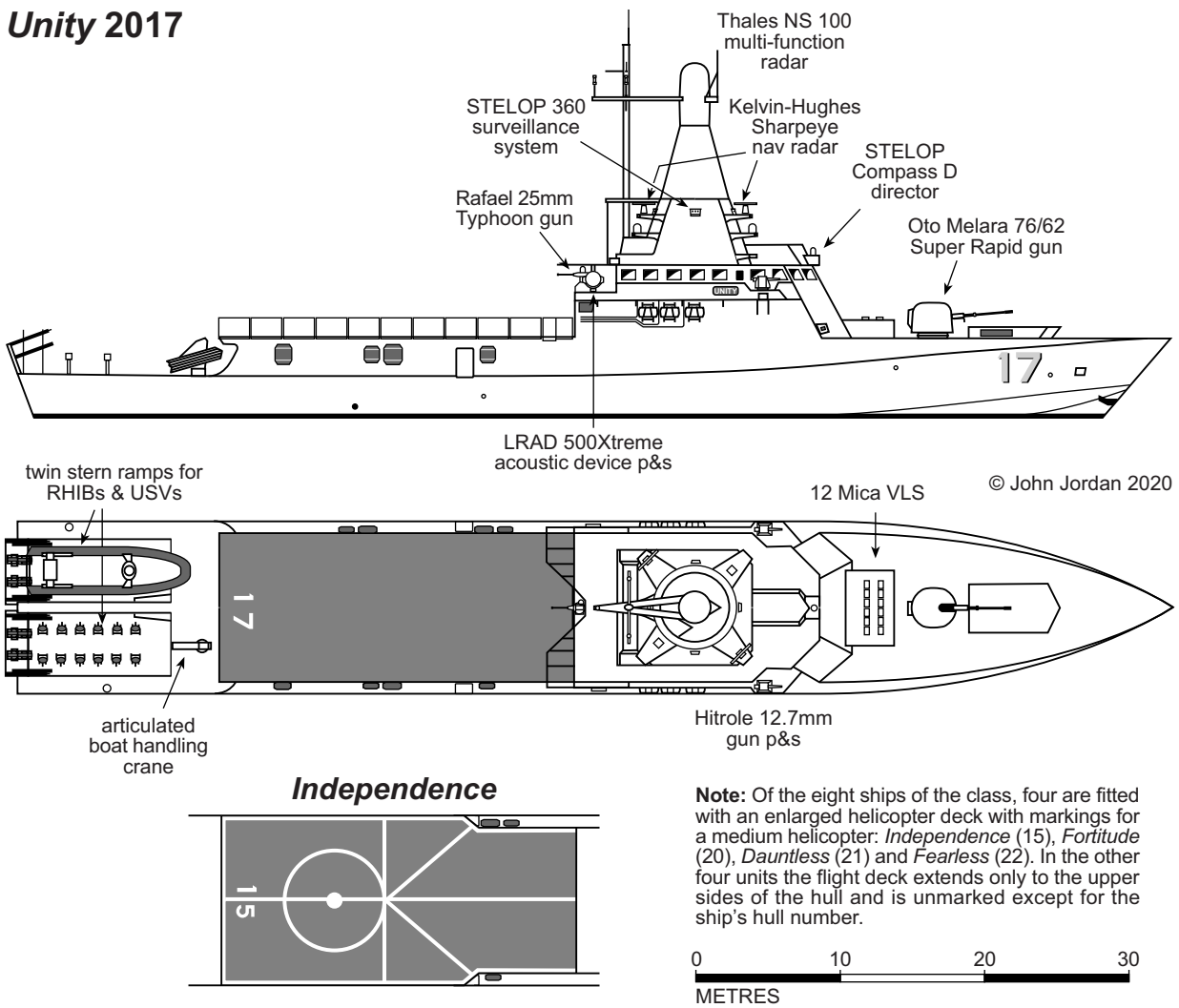
out platform systems integration and with its ST Electronics arm supplying and integrating the core combat system. Although sometimes officially described as a 'uniquely Singaporean' design, Saab Kockums has also played a significant role in the LMV programme. The Swedish company helped with the basic design – many sources suggest Saab's 'Flexpatrol' concept was an important design influence – and provided documentation for classification, such as Det Norske Veritas (DNV) certification. Moreover, its Karlskrona yard built all the ships' composite superstructures, shipping them to Singapore for integration.

Construction of the new class commenced with a steel-cutting ceremony in June 2014. Three months later, on 14 September 2014, the keel of the first vessel was laid at the ST Marine Benoi shipyard. The ship was launched by Mrs Ivy Ng, wife of the Minister for Defence, Dr Ng Eng Hen on 3 July 2015, taking the name *Independence*.[5] She was delivered in mid-2016 and finally commissioned on 5 May 2017, the fiftieth anniversary of the RSN's formation.

OVERALL DESIGN

Key data for the *Independence* class LMVs is provided in Table 3.2.1. With a length of 80m, a width of 12m and a draft of a little over 3m, the littoral mission vessels have a full load displacement of 1,250 tons. This makes them around two and a half times as heavy as the 500-ton *Fearless* class vessels they have been designed to replace. Particular attention has been paid to optimising the hull form to achieve an efficient hydrodynamic performance and thereby reduce fuel consumption. A bilge keel and active fin stabiliser arrangement helps to ensure stability.

The vessels are assembled from nineteen blocks, one of which is the carbon-reinforced plastic (CFRP) superstructure. The flush forecastle and flight deck are split by the superstructure block, with two further deck levels and the keel running below. There is a large mission bay underneath the flight


Unity 2017
Thales NS 100 multi-function radar
STELOP 360 surveillance system
Kelvin-Hughes Sharpeye nav radar
STELOP Compass D director
Rafael 25mm Typhoon gun
Oto Melara 76/62 Super Rapid gun
17
LRAD 500Xtreme acoustic device p&s
twin stern ramps for RHIBs & USVs
© John Jordan 2020
12 Mica VLS
17
articulated boat handling crane
Hitrole 12.7mm gun p&s
Independence
15
Note: Of the eight ships of the class, four are fitted with an enlarged helicopter deck with markings for a medium helicopter: Independence (15), Fortitude (20), Dauntless (21) and Fearless (22). In the other four units the flight deck extends only to the upper sides of the hull and is unmarked except for the ship's hull number.
0 10 20 30
METRES

deck, linked to a quarterdeck launching and recovery position for small boats at the stern. Moving upwards, the LMVs feature a spacious integrated bridge, combat information and platform management centre – the innovative ICC – with windows on all sides to provide a panoramic 360° view. The bridge is topped by a streamlined, cone-shaped integrated mast.

The hull is subdivided by watertight and gastight bulkheads, and the ship features a gastight citadel for most of its length to provide full chemical, biological, radioactive and nuclear (CBRN) protection. The LMVs are designed to stringent naval stability and damage resistance criteria, featuring good survivability for their size. Networked cameras and sensors monitor and control each vessel's status. There is also a very high degree of duplication of important equipment for mutual redundancy, extending to circuits and piping for critical control and circulation systems.

The response to fires, fumes and flooding is based on isolating the rooms subject to these hazards and providing redundant controls for relevant equipment, minimising the risk of any potential spread of smoke, heat or flooding. Damage control co-ordination is supported by the integrated monitoring and control element of the ship's platform management system – the 'Intruder Detection System' – made up of numerous sensors and more than sixty CCTV cameras. An elaborate alarm processing subsystem, using fire and flooding alarms, triggers the automatic display of relevant camera images at specific consoles. Firefighting equipment includes a salt water fire extinguishing system; a CO_2 extinguishing system in the machinery spaces and hazardous compartments; an aqueous film forming foam system for the flight deck, hangar and fuelling compartment; a deep fat fryer extinguishing system in the galley and numerous portable firefighting

Another view of *Sovereignty* showing the large superstructure block that houses her integrated command centre and her enclosed, integrated mast. Both features assist 360° visibility to provide a crucial advantage in littoral operations. There is a large mission bay underneath the flight deck linked to a launching and recovery position for small boats at the ship's stern. *(Guy Toremans)*

devices. The high level of automation is an important factor in achieving the important minimal crewing requirement.

INTEGRATED COMMAND CENTRE (ICC)

The LMVs are notable in packing quite an array of innovative and 'smart' technologies, most evident in the integrated command centre (ICC). They are the first RSN ships to feature this arrangement, which essentially co-locates the ship's navigation bridge, the combat information centre and the machinery control room in one large space. This combination is intended to provide seamless connectivity between 'driving' and 'fighting' the ship, accelerating situational awareness, decision making and response times to provide a critical advantage in littoral operations. The streamlining of workflow processes and enhanced co-ordination of personnel that the arrangement provides is also another crucial element in the effort to reduce overall crew numbers.

The ICC comprises five 'clusters' that are made up of multi-touch and gesture-based consoles, with integrated control panels and high-resolution colour monitors that display ergonomically designed graphical pages of the ship's systems.

Up front, on the port side, are the engineering consoles for the platform management system, whilst the navigation consoles are to starboard. The second row comprises the command cluster. This incorporates two large 46in (117cm) multi-purpose touch screens – one for the commanding officer; the other for the principal warfare officer. Moving further aft, the third row is made up of the surveillance cluster; the fourth row houses the weapons cluster (including weapon-specific stations for remotely-controlled weapons); whilst behind this is the network mission module cluster

Platform Management: The LMVs are endowed with a state-of-the-art integrated bridge and platform management system (IBPMS) developed by STE. Equipped with a comprehensive range of user interfaces and fully automatic malfunction and damage analysis technology, the IBPMS collects and monitors data from all shipboard systems including propulsion, generating and distribution equipment. The integrated CCTV network previously mentioned allows video monitoring of vital locations such as the machinery spaces and flight deck from the relevant ICC cluster. The IBPMS also

Two views of the integrated command centre (ICC) that is central to the littoral mission vessel's concept of operations. The consoles are arranged into functional clusters. The first row near the forward bridge windows contains the engineering and navigation cluster, with the command cluster with its two large multi-purpose screens immediately behind. The third row houses the surveillance cluster, whilst weapon control positions are in the fourth. A fifth row – out of view in these photographs – contains a network mission module cluster. *(Guy Toremans)*

A closer view of the littoral mission vessel's integrated mast, which houses the ship's principal sensors in easily accessible and weather-resistant positions. *(Guy Toremans)*

supports the automated performance of many navigation functions.

The information available from the multi-function consoles allows operators to identify platform status at all times and react within a very tight timeframe. An innovative messaging system using personal I-Phone type portable computers also allows crew members to receive automated status information via the ship's wireless network. If the ICC becomes damaged or is otherwise inaccessible, crew members can use these portables to plug into the IBPMS at designated locations in other parts of the ship.

The IBPMS also features a 'sense-making' module that performs real-time analysis of shipboard system data to provide information on the platform's underlying health status. Imminent equipment failures and other anomalies can therefore be detected at an early stage and advisory actions or instructions provided to inform both preventive as well as condition-based maintenance. The module is linked via the ship's communications facilities to the navy's shore-based Fleet Management System Centre in Changi Naval Base.

Combat Management: The combat management system (CMS) controlled from the ICC is also supplied by STE. It incorporates what is known as an advanced 'fusion and identification engine' to collate the myriad of information provided by the ship's sensors and manipulate these into a coherent picture of the maritime situation, identifying, tracking and managing potential threats. It also incorporates a threat evaluation and weapon assignment (TEWA) system to prioritise contacts of interest in the congested littoral environment on the basis of pre-defined criteria, assigning the most appropriate weapons to counter any threat. A new Sagem (Safran) gun fire-control system specially developed for the LMVs is integrated into the CMS. Controlled from the ICC, it can be operated from several consoles concurrently and can be used in conjunction with both main and secondary armament. It has similarities with the systems already installed in Singapore's *Endurance* class amphibious transport docks and *Formidable* class frigates, easing the overall maintenance burden.

SENSORS AND COMMUNICATIONS

A significant and visually prominent feature incorporated into the LMV design is the distinctive modular mast. This houses most of the ship's navigation and surveillance sensors, as well as many of its communication antennae. Made of composite material – with the key benefit of being completely transparent to electromagnetic waves – the mast provides sensors with a 360° field of view without any blind spots. Given the numerous transmitters and receivers working across a wide range of frequencies installed in this confined space, a major challenge in designing the mast was to achieve electromagnetic compatibility. Detailed studies and simulations were therefore carried out in close cooperation with the various systems' suppliers to avoid any interference between different sensors and ensure an optimal arrangement. The mast's structural design is particularly valuable in protecting sensors from weather elements whilst providing the crew with easy access to components within the mast, both in harbour or at sea. This is anticipated at reducing maintenance downtime for mast-related defects by up to 80 percent over a vessel's life.

Sensors: The *Independence* class's sensor suite is headed by a Thales NS100 3-D air/surface surveillance radar. Operating in the NATO E/F bands (US Navy S band), the NS100 is a dual axis, multi-beam active electronically scanned array (AESA) with beams simultaneously positioned in elevation as well as azimuth direction. It has a maximum instrumented range of c. 280km against aerial targets – 80km against surface targets – and performs particularly well in the cluttered littoral environments that are the LMV's principal operational arena. It is capable of performing search, target tracking and active seeker missile guidance functions, as well as supporting helicopter and unmanned aerial vehicle (UAV) control and surface gun fire support. The LMVs also mount two Kelvin Hughes 'SharpEye' navigation radars. Solid-state, high resolution systems, these radars have the ability to detect objects with very small radar cross sections such as rigid-hulled inflatable boats (RHIBs) and even submarine periscopes at considerable range and in cluttered conditions.

Situational awareness is enhanced by a ST Electronics' STELOP 360SS all-round surveillance system featuring a panoramic V360/V180 day/night camera suite. The LMVs are also equipped with a STELOP Compass D electro-optic director. The electronic warfare suite is Israeli in origin, being made up of an Elisra electronic support measure (ESM) and a Rafael electronic countermeasures (ECM) component.

Communications: Another key feature of the LMV design is its network-centric integrated communications suite (ICS), which encompasses both internal and external communications and enables the small crew to cope efficiently with the high-volume exchange of information. The ICS leverages on the Singapore Armed Forces' Integrated Knowledge-based Command and Control (IKCC) system. This provides access to real-time information and command expertise to enhance the ship's awareness and 'sense-making', whilst facilitating the sharing of data across all Singapore Armed Forces' assets.

This view of *Independence*'s forward bridge shows many of her key sensors. A STELOP Compass D electro-optic director is located on the centreline of the forward bridge roof, whilst two of the four sensor housings for the STELOP 360SS all-round surveillance system can be seen on the lower base of the mast. A 'SharpEye' navigation radar – one of two in the ship's outfit – is supported by upper starboard platform extending from the mast base. The main Thales NS100 3-D surveillance radar is housed within the integrated mast. Also visible is the starboard Oto Hitrole G weapons station on the bridge wing. *(Guy Toremans)*

WEAPONS SYSTEMS

The *Independence* class LMVs have a core outfit of weapons systems catering for both lethal and non-lethal responses. These weapons are supplemented by the class's ability to ship a range of modular and deployable systems tailored to particular mission requirements that is inherent in the LMV concept. The core outfit is focused on a single Oto 76/62 Super Rapid gun on the forecastle, a Mica air defence system immediately to its rear and just forward of the bridge, two 12.7mm Hitrole remote control weapons stations on the forward bridge wings and a 25mm Typhoon mount at the aft end of the bridge superstructure.

The ubiquitous Leonardo Defence Systems (LDS) Oto 76mm/62 Super Rapid gun has a selectable firing rate from single shot to 120 rounds per minute. It can be used against both air and surface targets. It has a maximum range of 16km with standard ammunition, 20km with extended range Oto SAPOMER shells or 40km with guided long range

A stabilised Rafael Typhoon weapons station is located on the littoral mission vessel's aft bridge superstructure in a centreline position. It is fitted with a 25mm Bushmaster cannon and a sensor package that includes an electro-optical director. *(Guy Toremans)*

(GLR) ammo. Automatic loading is provided through a below-decks revolving magazine, which holds eighty rounds.

The two LDS Oto Hitrole G remote control weapons stations (RCWS) are each fitted with a 12.7mm FN Herstal M2Hb/QCB machine gun. The mountings are fully stabilised and electrically operated and fitted with their own sensor package. An interface with the ship's combat management system means that they can be controlled from the ICC and benefit from data from other ship sensors. Rate of fire is between 450 and 550 rounds per minute and 400 'ready-to-fire' rounds are stored on mount.

The stabilised stern-facing Rafael Typhoon RCWS is fitted with a 25mm Bushmaster cannon and a sensor package including an electro-optical director. As for the Hitrole stations, the mounting is integrated with the ship's overall combat management system and operated from the ICC.

The MBDA Mica surface-to-air missile system is housed in a twelve-cell vertical launch system and provides a credible anti-air defence capability. An all-weather fire and forget missile weighing 112kg and 3.1m in length, it carries a 12kg warhead and has an interception range of up to 20km. A development of the air-to-air missile, it can be fitted with either an active radar or infra-red (IR) homing seeker. The system is claimed to have an extremely short reaction time and an excellent multiple target capability, thereby making it well-suited for defence against saturation attacks.

The LMVs' 'non-lethal' armament suite consists of two water cannons and two remote-controlled LRAD 500Xtreme long-range acoustic devices. The latter include high intensity xenon lights that can be remotely controlled over an IP network. They can be used to broadcast clear voice commands and attention-commanding deterrent tones over distances of up to 2,000m.

The *Independence* class units mount also two STE decoy launchers capable of deploying a full array of chaff and IR devices.

MODULAR SYSTEMS

In addition to their core armament, the LMVs are fitted out to deploy a range of other mission-specific

The multi-mission nature of littoral mission vessel tasking means that their weapons outfit must be suitable for dealing with a range of situations, some necessitating a non-lethal response. Two LRAD 500Xtreme long-range acoustic devices facilitate this approach. *(Guy Toremans)*

equipment to maximise their versatility. Notably, the aft section is dominated by a 300m² helicopter deck that allows the operation of a medium-sized helicopter such as the Sikorsky S-70B Seahawk. This can be fitted with a helicopter visual landing aids (HVLA) suite with a glide path indicator, a horizon bar, deck lighting and status lights for day and night operations. Although all eight LMVs have been built with the weight and strength to deploy a medium-lift helicopter from the flight deck, only the lead ship, *Independence*, and the last three ships in the class, *Fortitude*, *Dauntless* and *Fearless*, have been equipped with deck markings and landing aids. Images of the other four ships – *Sovereignty*, *Unity*, *Justice* and *Indomitable* – reveal a lack of landing area periphery and landing line-up lines, as well as the anti-skid coatings, typically found on the flight decks of helicopter-capable ships. This suggests these four ships will be used for rotary-winged unmanned aerial vehicle (UAV) operations. It is possible to deploy a catapult launcher and skyhook type recovery system for the operation of UAV in less than two minutes.

The LMVs are also configured with a 25m-long and 12.8m-wide mission bay that allows the installation of up to four, 20ft standard 'plug-and-play' containerised modules to allow the ship the ability to carry out a wide range of different tasks. The mission modules can be loaded into the mission bay through two hatches in the flight deck. The bay incorporates interface facilities such as power and communications cables, as well as multi-function consoles connected with the integrated command system. Modularised mission capabilities could extend to mine countermeasures, boarding operation support and even medical intervention.

The stern area of the ship features an ingenious double ramp system for the launching and recovery of up to two Zodiac Milpro 11.5m rigid hull inflatable boats RHIBs or the STE-developed Venus unmanned surface vessels (USVs).[6] The slipway contains rollers and moving pans that allow swift launch and recovery of the boats in conditions up to Sea State 4. This process can be completed by two crew members in two minutes, compared with in 15 minutes by five sailors on the older patrol vessels. If

The mission bay in *Independence*, looking forward. Immediately ahead is a position for a standard 20ft container, accessible from a hatch in the flight deck above. The 320m² mission bay can house up to four containers to support a range of specific operations. *(Guy Toremans)*

Each littoral mission vessel is fitted with twin launching ramps for RHIBs and USVs aft of the mission bay. The slipway contains rollers and moving pans that allow swift launch and recovery of the boats in conditions up to Sea State 4. *(Guy Toremans)*

needed, the ramp can be covered up with a temporary deck to provide space for an additional four, 20ft standard containers. This would allow, for example, the deployment of additional weapons and sensor packages, such as twin canisters for Harpoon surface-to-surface missiles or an Atlas/STE variable-depth sonar and B515 triple torpedo launchers for Whitehead A244S anti-submarine torpedoes.

Singapore has been one of the world's leading navies in the operation and development of USVs, providing the LMV with further mission flexibility. Particularly noteworthy was its deployment of the 9m Rafael Protector USV on board the *Endurance* class amphibious transport dock *Resolution* during the ship's three-month deployment to the Northern Arabian Gulf in 2004, where the system was used to protect critical infrastructure from potential terrorist attack. Various iterations and sizes of the indigenous Venus USV have been put into service, most recently anti-submarine, mine countermeasures and coastal defence variants of the large Venus 16 type.

CREW AND ACCOMMODATION

In line with the lean manning philosophy driving the LMV design and the associated focus on automation, each *Independence* class ship can operate

The *Independence* class's combination of a relatively large ship with a small crew allows for excellent standards of habitability, as demonstrated by these photographs taken on board the lead ship. The top two images show the commanding officer's cabin and office, whilst the bottom left photo is of the officers' wardroom. Separate recreational spaces are provided for commissioned officers, petty officers and ratings but there is a single dining hall. The bottom right image illustrates the galley. In line with the emphasis on minimal crewing, it incorporates a number of innovations to reduce demands on the catering staff, most notably a system to steam-cook pre-frozen food. *(Guy Toremans)*

Independence pictured at the time of her initial delivery in May 2016. She is equipped with a combined diesel and diesel (CODAD) propulsion system that combines a high maximum speed with good endurance. *(Singapore Ministry of Defence)*

with a core crew of just twenty-three, of which five are commissioned officers. This has been claimed to be around half that of a comparable vessel. There are sufficient berths for an additional thirty-eight mission-specific personnel. The combination of a relatively large size with this small complement makes for a spacious ship with high standards of crew accommodation. The majority of the crew have spacious two-berth cabins, with only junior ratings allocated four- or six-berth billets.

Dining facilities are concentrated in a single area shared by all ranks. However, separate recreational spaces are provided for commissioned officers, petty officers and ratings. The galley incorporates a number of innovations to reduce demands on the catering staff, most notably the use of a system to steam-cook pre-frozen food and of induction cookplates. Each ship's medical facilities include a treatment room and a pharmacy.

The minimal complements aboard the LMVs mean that crews have to be capable of performing multiple roles. Their training has been assisted by the development of a Littoral Mission Vessel Simulation Centre – RSS *Daring* – that contains two identical simulation halls that are mock-ups of an LMV's ICC. The simulation centre employs technology to allow training to be performed in various realistic conditions and environments, enabling crews to be ready to deal with similar conditions when at sea.

PROPULSION

The LMVs are powered by a Combined Diesel and Diesel (CODAD) arrangement utilising four Rolls-Royce Power Systems MTU 20V 4000 M93L diesel engines each rated at 4,300 kW. These are connected to two shafts fitted with controllable pitch propellers through two Siemens Navilus gearboxes in a paired arrangement. Two engines are located in each of the two principal machinery spaces for reasons of redundancy. Maximum speed is in excess of 27 knots; considerably greater than the 20 or so knots achievable by the previous *Fearless* class. Endurance is officially quoted as being 3,500 nautical miles at cruising speed, with sufficient provisions being carried to sustain 14-day deployments.

TESTS AND TRIALS

Bringing a new class of warships into service is always challenging. However, Lieutenant-Colonel Chew Chun Chau – head of the LMV project

Table 3.2.2: INDEPENDENCE LMV CLASS LIST

NAME	PENNANT	ORDERED	LAID DOWN	LAUNCHED	COMMISSIONED
Independence	15	30 January 2013	11 September 2014[1]	3 July 2015	5 May 2017[2]
Sovereignty	16	30 January 2013	14 May 2015	16 April 2016	14 November 2017
Unity	17	30 January 2013	26 November 2015	13 October 216	14 November 2017
Justice	18	30 January 2013	26 May 2016	19 March 2017[3]	26 September 2018
Indomitable	19	30 January 2013	11 November 2016	23 September 2017	26 September 2018
Fortitude	20	30 January 2013	March 2017	24 March 2018	31 January 2020
Dauntless	21	30 January 2013	20 October 2017	18 August 2018	31 January 2020
Fearless	22	30 January 2013	12 April 2018	26 January 2019	31 January 2020

Notes:
1. First steel was cut in June 2014.
2. Delivered for trials and work up in May 2016. The other class members were delivered some months before commissioning into the operational fleet.
3. There is a discrepancy in the launch dates between the ST Engineering and Singapore Ministry of Defence press releases, the former stating launch on 18 March 2017.

office from 2010 to 2018 – told *Seaforth World Naval Review*, 'When RSS *Independence* went to sea for the very first time we were pleasantly surprised to see that everything worked far beyond our expectations. Even during rough seas the ship proved to be very seaworthy and manoeuvrable. In fact the trials were so successful that the navy was able to shorten the sea acceptance tests (SAT) period for the two following units, RSS *Sovereignty* and RSS *Unity*.' One of the factors explaining such satisfactory results is believed to have been a rigorous system of factory acceptance tasks undertaken before equipment was installed on board ship to ensure everything worked to the RSN's stringent requirements.

Table 3.2.2 gives a list of key construction dates for the vessels of the class. The lead ship,

Independence pictured at sea in the course of an extensive series of trials that culminated in her being certified as fully operational by the time of her formal May 2017 commissioning. An interesting detail of this photograph is that the twelve cells for her Mica vertical launch system have yet to be installed. *(Singapore Ministry of Defence)*

A pleasing feature of the *Independence* class's entry into service was the extent to which everything worked beyond expectations, enabling the trials of later vessels to be shortened. By late 2017, it proved possible to embark on the type's inaugural overseas deployment, when *Independence* herself sailed to Thailand to take part in the AMNEX 2017 exercises. Afterwards, she participated in an international fleet review held in Pattaya Bay on 19 November, where this photograph was taken. *(Arjun Sarup)*

Independence, was delivered in May 2016. She underwent an intensive series of harbour acceptance tests and first phase sea trials before returning to base to perform the final checkout, integration and testing of her weapons systems. From early October 2016, further testing was conducted on her combat management system. These culminated in *Independence* being certified as 'fully operationally capable' before 5 May 2017, the day of her official commissioning into the fleet. She subsequently participated in Singapore's first international review held to mark the navy's golden anniversary.

In November 2017, in a demonstration of her range and operational endurance, *Independence* sailed on an inaugural overseas deployment to Thailand to take part in AMNEX 2017, the first multilateral naval exercise of the Association of Southeast Asian Nations (ASEAN). This was followed by an international fleet review held in Pattaya Bay on 19 November as part of ASEAN's own 50th anniversary celebrations. Subsequently, in April 2018 she deployed to Surabaya in Indonesia for the annual bilateral 'Eagle Indopura' exercise. A tangible example of the class's role in security cooperation between Singapore and Indonesia came in March 2020 when *Independence* was involved in monitoring an incident that resulted in Indonesian forces detaining three criminals who had boarded a Liberian-flagged bulk carrier, *Sam Jaguar*, in the Singapore Strait.

Independence's delivery has been progressively followed by that of other members of the class under a programme of deliveries that has kept closely to the originally planned schedule. The second unit – *Sovereignty* – was delivered on 19 December 2016, subsequently participating in a series of shipborne trials of the Schielbel S-100 Camcopter rotary UAV during 2017. She was commissioned on 14 November 2017, the same day as the third member of the class, *Unity*. The fourth and fifth vessels – *Justice* and *Indomitable* – were officially

A CCTV 'grab' of *Independence* and a Singapore police boat keeping watch on the Liberian-flagged bulk carrier, *Sam Jaguar*, in the Singapore Strait in March 2020. The Republic of Singapore Navy assisted in a collaborative operation that saw Indonesia detain three pirates who had boarded the vessel. *(Singapore Ministry of Defence)*

inducted into the fleet on 26 August 2018. The programme concluded with the commissioning of the three final LMVs – *Fortitude*, *Dauntless* and *Fearless* – at Tuas Naval base on 31 January 2020. All in all, the programme delivered eight littoral mission vessels into the operational fleet within a span of just four and a half years.

All LMVs are assigned to the RSN's 182 Squadron, the main operational component of the Singapore Armed Forces' Maritime Security Task Force (MSTF). Operating out of Tuas Naval Base in western Singapore, Squadron 182 works with Singapore's law enforcement and maritime agencies to guard the nation's coastal maritime domain, including conducting daily patrols as well as boarding and escort operations in the Singapore Straits. Their mission portfolio includes search and rescue, counter terrorism, anti-piracy, customs enforcement, anti-smuggling, Special Forces and even limited humanitarian assistance and disaster relief operations.

CONCLUSION

After a lengthy process of brainstorming, developing, implementing and applying new technologies, testing and building, the RSN has achieved a ship in the form of the *Independence* class LMV that represents an evolution in equipment but a revolution in overall design. Totally customised to the RSN's operating environment and requirements, the LMVs are ideally suited to taking on the challenges of both today's and tomorrow's security needs in Singapore's littoral waters. Moreover, their excellent sea-keeping abilities and greater endurance will facilitate deployment at greater distances and for longer durations, helping Singapore's sea service to play its part in contributing to regional maritime security.

The launch of the eighth and final littoral mission vessel, a new *Fearless*, from the ST Marine Benoi shipyard on 26 January 2019. The Benoi facility has built all eight *Independence* class vessels. *(Singapore Ministry of Defence)*

Right: The final three littoral mission vessels were commissioned at a ceremony at Tuas Naval Base on 31 January 2020. All LMVs are assigned to the RSN's 182 Squadron, the main operational component of the Singapore Armed Forces' Maritime Security Task Force (MSTF) that is tasked with protecting the country's littoral waters. *(Singapore Ministry of Defence)*

With all eight littoral mission vessels now fully operational, the RSN is looking forwards to the successors of its six 1990s-vintage *Victory* class missile corvettes, which were designed by Germany's Lürssen and commissioned between August 1990 and May 1991. Current plans envisage their replacement on a one-for-one basis with a new multi-role platform – the multi-role combat vessel (MRCV) – from the middle of the current decade onwards.

The specific configuration of the new MRCVs has yet to be released given the programme is still in its initial development phase. However, RSN statements suggest that the basic factors influencing the LMVs will also hold good for the new, larger MRCVs. More specifically, the MRCVs will be custom-built for lean manning, aided by the use of technology to automate many functions. This will allow them to operate with fewer crew members and at less cost than comparable frigates. They will also be capable of deploying unmanned air and sea drones to extend their reach and flexibility against threats. Shipbuilders have already put forward a number of concepts in line with Singapore's new requirements, most notably STE's 'Vanguard 130' and the 'Crossover 131 Combatant' variant of Damen's Crossover series. Both concepts have a displacement in the order of 5,000 tons and are around 130m in length. Given Singapore's focus on the development of its indigenous defence industry, it seems almost certain that the design eventually selected will be built in a local yard.

In the meantime, the Republic of Singapore Navy can be well satisfied with the timely execution of the LMV programme. It clearly intends to become both sharper and smarter in order to remain fit to meet evolving challenges. The littoral mission vessels are a clear sign of this resolve.

Notes

1. The Singapore Naval Volunteer Force ensign was hoisted for the first time on 5 May 1967, with the title Republic of Singapore Navy finally coming into use on 1 April 1975. For more details of the RSN's evolution, see Mrityunjoy Mazumdar's 'Republic of Singapore Navy: To Defend and Deter', *Seaforth World Naval Review 2019* (Barnsley: Seaforth Publishing, 2018), pp.70–81.

2. Thirteen *Fearless* class patrol vessels were originally built. One – *Courageous* – was removed from service in 2003 after being damaged in a collision. The remainder have been steadily decommissioned as the *Independence* class have been inducted into the fleet, with only two active as of mid-2020.

3. The DSTA implements defence technology plans, acquires defence equipment and supplies, and develops defence infrastructure for Singapore's Ministry of Defence. It seems that one of the major inspirations for the LMV was a video by Apple founder Steve Jobs introducing the hybrid of a mobile phone and laptop – the I-Phone. The I-Phone's essential attributes – the flexibility to undertake a wide range of tasks whilst being easy and straightforward to use – were felt to be those that the new vessel should also aspire to.

4. A detailed description on the approach DSTA adopted to designing and validating the 'lean manned' ICC that forms a key part of the LMV concept was provided in an article 'Designing and Validating the Optimised Manning Concept of the Littoral Mission Vessel' in the *DSTA Horizons* 2017 journal (Singapore: DSTA, 2017), pp.4–9, available by searching the dsta.gov.sg website.

5. RSS *Independence* is the third in RSN history to carry the symbolic name of *Independence*. The name was originally given to the first ship acquired by Singapore after gaining independence.

6. The RHIBs are powered by a pair of 400hp engines providing a maximum stated speed in excess of 40 knots and can carry up to fifteen personnel, although seating can be removed to increase payload.

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3.3 SIGNIFICANT SHIPS

TYPE 23 FRIGATES

The Evolving Face of the Royal Navy's Workhorses

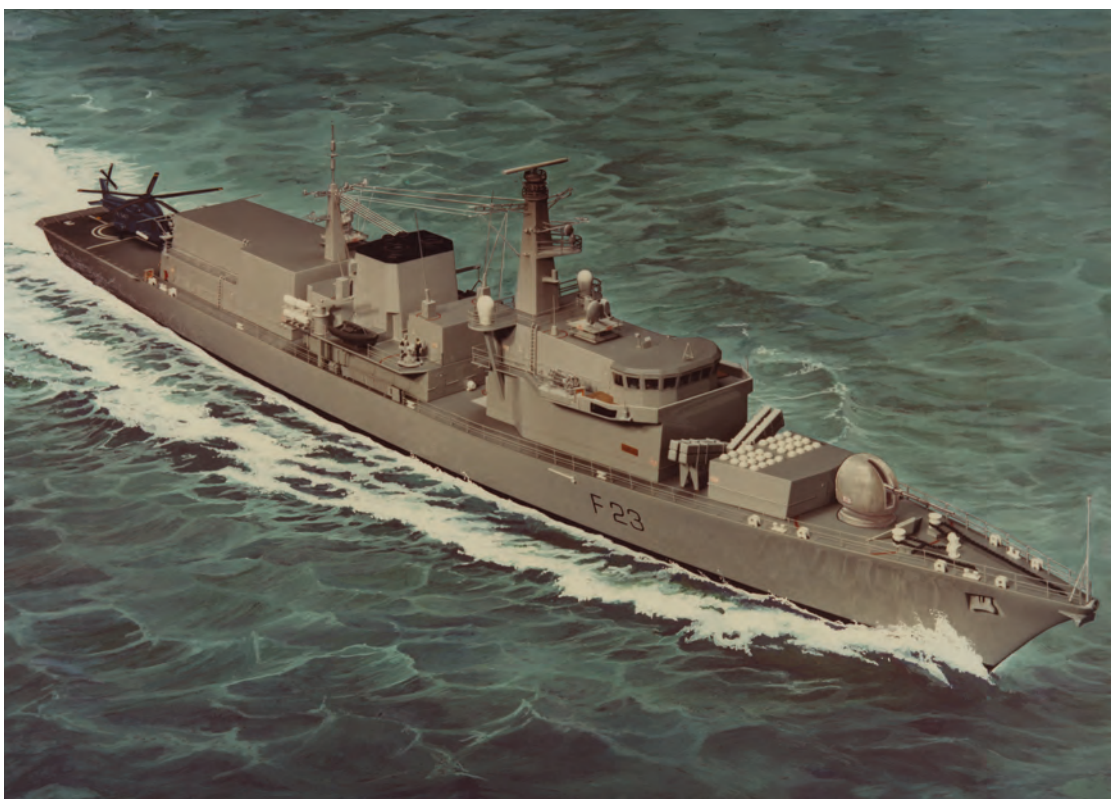
Author:
Conrad Waters

Initially conceived as specialist anti-submarine hunters intended for service in the North Atlantic, the British Royal Navy's Type 23 'Duke' class frigates entered service from 1990 onwards. The expected lifespan of each ship on entering service was some 18 years. Subsequent decades have seen the sixteen members of the class deployed across the globe to perform a wide range of roles. Moreover, an ongoing series of upgrades has nearly doubled the frigates' anticipated service lives; current plans envisage it will not be until the mid-2030s that the last of the class finally decommissions. This chapter looks at the evolution in the class's mission profile and capabilities from its origins to the current day.

TYPE 23 CLASS ORIGINS

The Type 23 frigates have their origins in the middle of the Cold War and the Royal Navy's primary focus on anti-submarine warfare in the North Atlantic. The navy's then current anti-submarine frigate – the Type 22 – was both large and expensive. Consequently, there was increasing pressure to develop a cheaper design against a backdrop of increasing financial pressures that would ultimately result in the imposition of severe reductions to the Royal Navy's size and structure in the Defence White Paper of June 1981.

The Outline Staff Target for a light anti-submarine frigate – the Type 23 – was issued in early 1981.[1] The main focus of the design was the ability to deploy a towed array – Type 2031Z – for the long-range passive detection of Soviet submarines. This focus also drove a requirement for an acoustically stealthy design that could quickly sprint to the general area of a suspected submarine before operating slowly and silently as it hunted its prey. Equally, good endurance was necessary to ensure that the ship could remain on



The original Type 23 design was intended to be a specialised light anti-submarine frigate. However, a series of design changes made both before and after the 1982 Falkland Islands War resulted in a much more flexible and capable design, illustrated in this image from the mid-1980s. *(Author's collection)*

Opposite: The Type 23 'Duke' class frigate *Kent* pictured departing Portsmouth Harbour on 1 June 2020, 30 years to the day since the first member of the class, *Norfolk*, was commissioned. Originally intended to be specialised anti-submarine frigates focused on North Atlantic operations and with 18 year lifespans, the Type 23s have served for decades in multiple roles across the globe. *(Conrad Waters)*

Ordered from Yarrow (Shipbuilders) Ltd in 1984, the lead member of the Type 23 class – *Norfolk* – was formally commissioned on 1 June 1990 after an extensive series of first of class trials. This picture dates from around the time of her completion. *(Author's collection)*

station. These factors ultimately drove the adoption of an innovative combined diesel-electric and gas propulsion system. The frigate was also to be equipped with a hull-mounted sonar and to have the ability to land and refuel a large helicopter to prosecute the targets it identified. There was a significant emphasis on radar stealth.

The major constraints on the Type 23 design were unit cost and the associated issue of crew size. At the time the Staff Target was endorsed in November 1981, the former was set at £67m (at 1980 prices) whilst accommodation was to be provided for 165 personnel.[2] These figures were less than two-thirds those of the contemporary Type 22 Batch 2 frigates. The impact of the tight budgetary envelope was reflected in a series of early design studies that drew heavily on previous light frigate concepts, the confusingly designated Type 24 and Type 25 designs.[3] Particularly significant capability omissions were lack of a hangar – it was envisaged that helicopters would be based and maintained on supporting ships – and a point defence missile system (PDMS).

As design development progressed, capability crept upwards. Ironically, this partly reflected the fact that the cancellation of other surface warship programmes as a result of the 1981 Defence White Paper meant that the Type 23 was likely to be the only major surface combatant to be ordered for the Royal Navy in the foreseeable future. An increase in the projected budget to £75m (still in 1980 terms) allowed the design to be recast with enhancements that included a basic hangar and Sea Wolf PDMS. Later, in the course of the design approvals process, further improvements added a second tracker for Sea Wolf to double its channels of fire and another gas turbine to increase top speed. These revisions were accompanied by a steady growth in size. By the time a further 3m had been added to hull length to allow the operation of a Sea King helicopter, waterline length amounted to 118m.[4]

Construction of the Type 23 frigates was split between Yarrow on the Clyde and Swan Hunter on the River Tyne. This picture shows *Northumberland*, one of the Swan Hunter-built ships, immediately before launch in April 1992. *(Author's collection)*

The Type 23 frigate *Westminster* and the *Fort Victoria* class replenishment oiler *Fort George* pictured fitting out at Swan Hunter in late 1992 or early 1993. Initial concepts for the Type 23 design envisaged the class's operations being supported by ships such as *Fort George,* which – in addition to providing liquid and solid replenishment – would also maintain the Merlin helicopters destined for the class. The adoption of a hangar before the design was finalised provided the class with greater operational independence. *(Author's collection)*

Montrose seen at speed whilst operating the Persian Gulf in January 2020. The Type 23 design followed the same general design principles as previous Royal Navy anti-submarine frigates, adopting a hull form optimised for sustained speed in adverse weather conditions. *(Crown Copyright 2020)*

The experience of the 1982 Falklands War resulted in further changes. Most obviously, a previously specified 76mm gun was replaced with the larger Mk 8 4.5in (114mm) mounting to provide for the naval gunfire support role. Less visually apparent but arguably of more significance were revisions to internal arrangements to increase the number of self-contained zones to resist the spread of fire and smoke. Other modifications reflecting Falklands' experience included increased splinter protection, an upgraded high pressure salt water (HPSW) system and a re-siting of mess decks higher in the ship to speed movement of personnel to their action stations. In a non-Falklands related improvement, the newly-developed vertical launched variant of Sea Wolf was substituted for the trainable launcher initially proposed. Waterline length increased to 123m as a result of the combined effect of these changes and accommodation increased to 185. Inevitably, there was also further cost growth.

Detailed design work on the Type 23 class was carried out by Yarrow Shipbuilders Ltd (YSL) on the Clyde, then a subsidiary of British Shipbuilders but now part of BAE Systems. All-in-all, it was estimated that YSL was responsible for around 85 percent of the total Type 23 design effort.[5] The yard was also awarded the order for the lead Type 23, *Norfolk*, in October 1984 and the ship was laid down on 14 December 1985. The original intention appears to have been to order subsequent three-ship batches on an annual basis but financial constraints and, later, the end of the Cold War meant that actual procurement was slower. In total, sixteen ships had been ordered when the final batch of Type 23s was contracted in 1996. This makes the Type 23 one of the more numerous classes of surface combatants to be completed in the post-Cold War era.

Norfolk was launched on 10 July 1987 and commissioned into the Royal Navy on 1 June 1990. Thirteen of the class had been delivered by 1997. However, post-Cold War spending reductions had a particularly marked impact on the later ships and it was not until 2002 that the final unit, *St Albans*, entered service. Twelve of the class were built by YSL, with Swan Hunter on the Tyne completing the other four. First of class *Norfolk* cost a total of £135.4m in cash terms but subsequent ships were significantly cheaper. Although precise comparisons are difficult to make in the absence of hard data and given the distorting effect of inflation, it seems that Type 23 unit cost was around three-quarters of a preceding Type 22 frigate on an inflation-adjusted basis. Whilst still cost-constrained, the various changes made to the Type 23's specification to produce a more balanced and resilient design ultimately meant that it was not a cheap ship.

DESIGN DESCRIPTION AS BUILT

Overview: Displacing around 4,200 tons at full load displacement when first entering service, the Type 23s are far removed from the light frigates initially

This 2012 aerial view of *St Albans* provides a good indication of the ship's upper deck layout. The superstructure is effectively divided into four blocks; from forward to aft these are (i) the Sea Wolf missile block, (ii) the bridge structure and forward mast, (iii) the central upper auxiliary machinery and uptake block and (iv) the large helicopter hangar and torpedo magazine. The arrangement facilitates access from port to starboard and also provides natural fire breaks between the different superstructure elements. *(Crown Copyright 2012)*

envisaged. Indeed, overall dimensions are broadly similar to those of the Type 22 Batch 1 frigates and significantly larger than the *Leander* class vessels they were destined to replace. Their hull forms follow the practice of using a deep and narrow 'V'-shaped forebody broadening out into a fuller form aft that was first established in the 1950s-era Type 12 frigates, facilitating the maintenance of a high speed in difficult weather conditions. However, the breadth to length ratio is increased in comparison with previous designs and there is also a slight growth in freeboard. The hull is flared along its entire length, reducing radar cross section and further assisting stability.[6] Following advice from the Y-ARD consultancy, a hybrid hull structure was adopted by which conventional longitudinal framing of the strength deck and ship's bottom was combined with a transversely framed side structure more usually found in merchant ships. This reduced construction cost at the penalty of a c. 40-ton increase in weight. Deep bilge keels and integral fin stabilisers were specified for stabilisation purposes.

The class's 123m waterline/133m overall length was adopted as the minimum necessary for a satisfactory deck layout whilst still allowing the class to be accommodated within the constraints of the Frigate Refit Complex at Devonport. Superstructure is split into four separate blocks. That furthest forward originally housed the class's outfit of thirty-two vertically-launched Sea Wolf missiles. In an arrangement echoed by the later Type 45 destroyers, this structure also splits the forward 4.5in gun from the mountings for the outfit of Harpoon surface-to-surface missiles. Moving aft, the bridge block also provides accommodation for the ship's officers and forms the base of the principal mast structure. A further gap – required to ensure separation between the ship's uptakes and sensitive electronics as well as allowing access to below decks machinery – precedes the broadly central upper auxiliary machinery block. This is, in turn, split from the large, after-most hangar block. Large enough to house a Merlin helicopter, the hangar block also incorporates the air weapons magazine and the ship's fixed torpedo tubes towards its forward end.

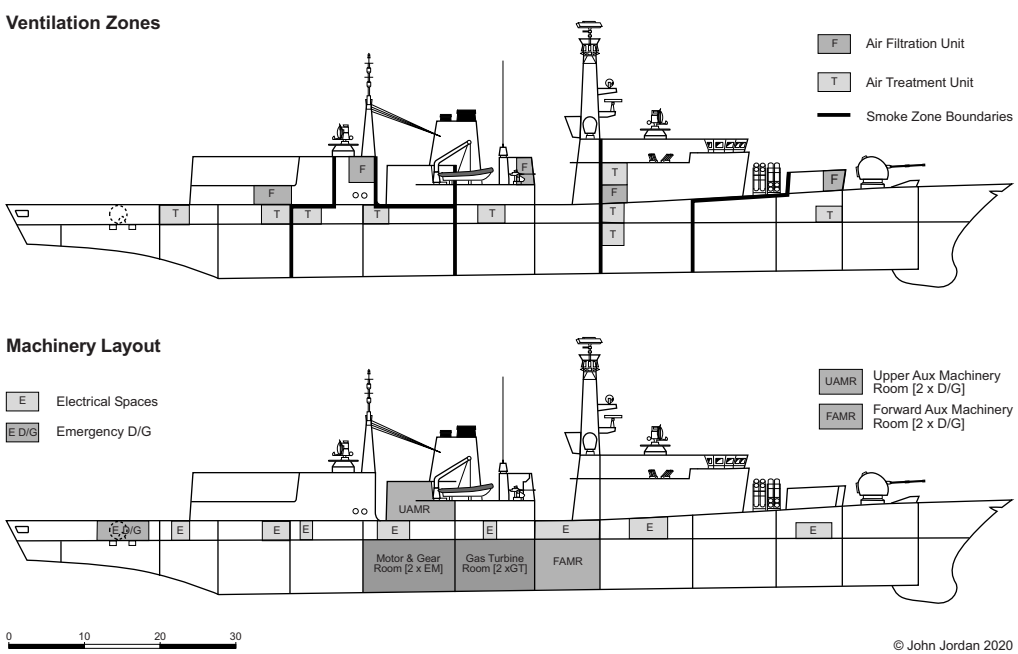
Survivability and Stealth: The Type 23's block structure provides natural firebreaks between each element of the superstructure whilst facilitating clear access between port and starboard sides of the ship. The approach is just one example of the emphasis on survivability inherent inherent in the design. As previously mentioned, survivability was significantly upgraded as a result of the Falklands War, most notably through an increase in the self-contained damage control (fire) zones from three to five. Each of these zones contains its own damage control centre and air filtration system. Ventilation trunking is not allowed to cross the zone boundaries. The various zones are separated by protected transverse bulkheads, with good vertical access being provided in each zone. In a departure from previous practice, all main bulkheads are also watertight up to No.1 deck.

The Falklands' experience also influenced improvements to the HPSW ring main, including the addition of a low level cross-connection, more resilient pumping arrangements and the ability to operate valves from the open decks. An extensive surveillance system – now a common feature of modern warship designs – was specified to provide the ship control centre with a more immediate and effective picture of overall ship status. Detailed changes include a significant reduction in internal linings (which had been shown to obstruct fire-fighting and leak-stoppage), as well as an increase in the size of emergency manholes to facilitate access by sailors carrying bulky emergency equipment.

In an approach that predated the Falkland Islands' campaign, the Type 23 is also notable for being one of the first warships that focused on achieving stealth across a broad range of emissions. Whilst not as obviously stealthy as the subsequent French *La Fayette*, much effort was devoted to minimising radar cross section (RCS) by avoiding re-entrant corners throughout the external design. The hull – as previously noted – is flared outwards, whilst the superstructure is angled inwards and the main deck slanted to the horizontal. Attention was also paid to reducing the signatures of external fittings, extending even to the rungs of the upperdeck ladders. Radar-deflecting baffles are fitted in the vicinity of equipment whose RCS cannot be reduced. A new degaussing system was also developed to limit magnetic signature.[7]

Propulsion: The Type 23 class's most notable contribution to stealth is, however, in the area of

The need for stealth played a key feature of the Type 23 design, including extensive measures to minimise the ship's radar cross section. This picture of *St Albans* in 2015 illustrates the efforts made to avoid re-entrant corners throughout the superstructure, giving a significantly different appearance compared with previous Royal Navy frigates. *(Conrad Waters)*



These internal diagrams of the Type 23 illustrate some of the measures adopted to ensure survivability and acoustic stealth, two principal objectives of the final design.

propulsion. The frigates adopted a then-novel combined diesel-electric and gas (CODLAG) propulsion system that drew heavily on work for the previous abortive Type 24 design. It employs two low power (1.5MW) DC propulsion motors fed by the ship's diesel generators. One motor is connected directly to each of the two shaftlines for slow-speed, quiet operation. The electrical motors are supplemented by mechanical drive for higher speed sprints by use of two, more powerful (initially 12.8MW) gas turbines. One is linked mechanically to each shaftline via a gearbox. Large, slow-running fixed pitch propellers are fitted for reasons of silence and economy, with the specification of non-reversing gearboxes mandating the use of electric drive for low-speed manoeuvring. Maximum speed using the Rolls-Royce Spey SM-1A turbines fitted to earlier class members is officially stated as being 28 knots. Up to 15 knots can be achieved in diesel-electric drive whilst endurance is an impressive 7,800 nautical miles. Electrical power is supplied by four diesel generators, the 1.3MW Paxman Valenta 12RP200CZ being installed on completion. An integrated 600/440 V power supply system was specified to cater for the specific needs of both the propulsion motors and shipboard 'hotel' and weapons systems. An additional 250kW emergency diesel generator capable of autonomous operation was also mandated. It is located under the flight deck.

The emphasis on stealth is evident throughout the Type 23 class's propulsion system's design. The diesel generators are arranged in pairs. One of these pairs is mounted at main-deck level in an upper auxiliary machinery room, where the generators are less likely to pass noise and vibration into the sea. The other pair is located in the forward auxiliary machinery room ahead of the gas turbine compartment in a more conventional position low in the ship, with silencing provided by means of rafting and acoustic hoods. The frigates were widely-touted as the world's most quiet surface warships when they first entered

Table 3.3.1.

HMS LANCASTER PRINCIPAL PARTICULARS (ON COMPLETION)

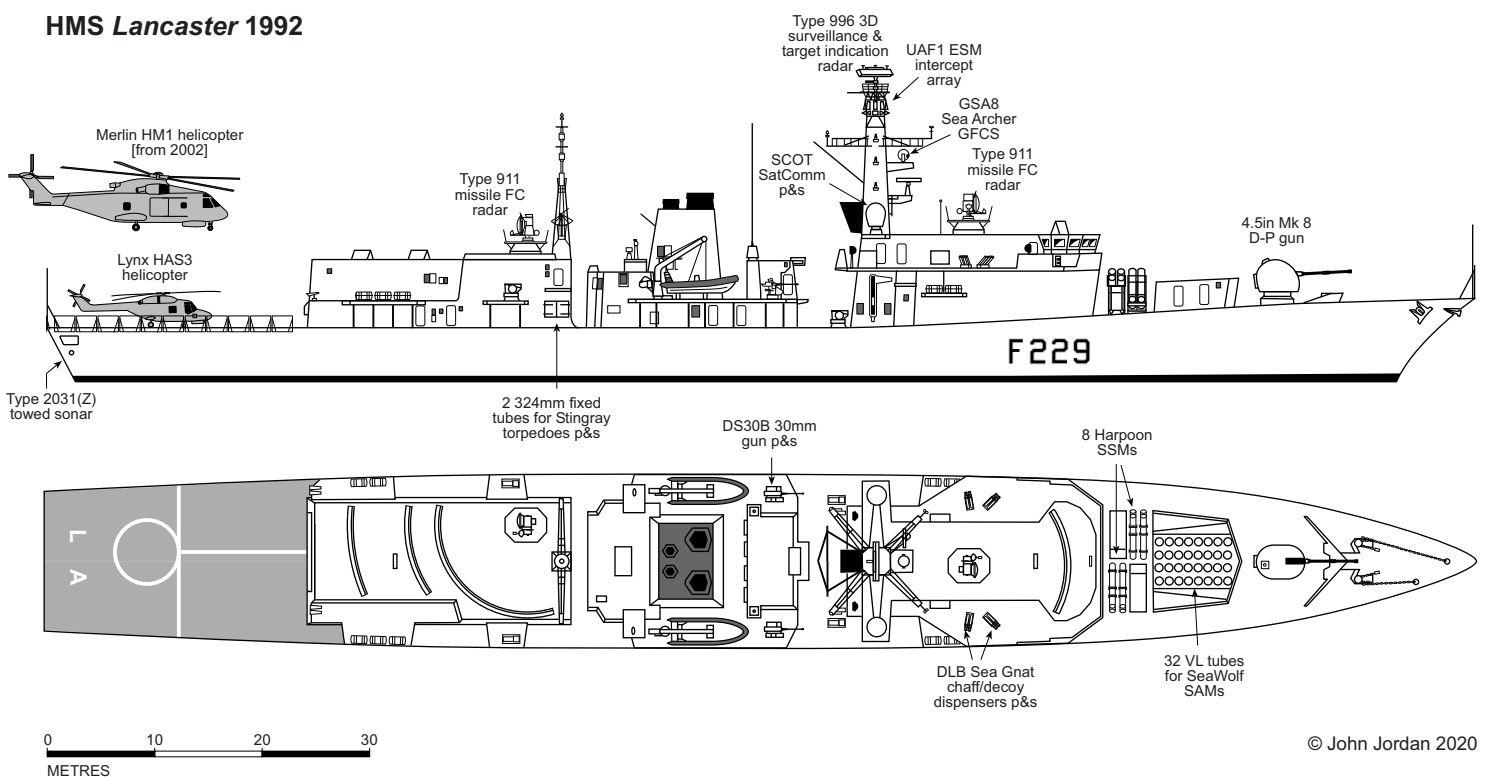
Building Information:					
Laid Down:	18 December 1987	**Launched:** 24 May 1990		**Commissioned:**	1 May 1992
Builders:	Yarrow (Shipbuilders) Limited, Scotstoun				
Dimensions:					
Displacement:	c. 4,200 tons full load displacement.				
Overall Hull Dimensions:	133.0m x 16.1m x 5.5m (7.3m sonar). Waterline length is 122.0m				
Equipment:					
Missiles:	32-cell VLS for Sea Wolf (GWS 26 Mod. 1) surface-to-air missiles 2 x quadruple launchers for Harpoon surface-to-surface missiles.				
Main Guns:	1 x 114mm Mk 8 gun, 2 x 30mm DS30B cannon.				
Torpedo Tubes:	2 x twin 324mm for Stingray light torpedoes.				
Countermeasures:	4 x Sea Gnat (Outfit DLB) decoy launchers, Type 182 towed decoy.				
Aircraft:	Flight deck and hangar for one medium-sized helicopter. Lynx HAS 3 embarked on completion.[1]				
Principal Sensors:	Type 996 surveillance & target indication radar. 2 x Type 911 fire-control radars. Navigation radar. Type 2050 bow-mounted sonar. Type 2031Z towed array.				
Combat System:	Outfit DNA(1) CMS.[2] Outfit UAF-1 RESM. Comprehensive communications including NATO Link 11.				
Propulsion Systems:					
Machinery:	CODLAG. 4 x Paxman Valenta 12 RP200CZ diesel generators each rated at 1.3MW provide power for 2 x 1.5MW GE electric motors and hotel services. 2 x Rolls-Royce Spey SM-1A gas turbines each rated at c. 13MW for sprint speed. Twin shafts.				
Speed:	28+ knots. Endurance is 7,800 nautical miles at 15 knots. .				
Other Details:					
Complement:	Normal crew of 170 including 15 officers. Accommodation is provided for 185 personnel.				
Class:	See Table 3.3.2. *Lancaster* was the fourth member of the class to commission.				

Notes:
1. Merlin HM1 from 2002.
2. Not fitted on completion.

service. They still retain much of this advantage some 30 years later. Special measures were also taken to reduce infra-red (IR) signature. So-called 'cheese-graters' were fitted to the main exhaust outlets to mix air from the ship's ventilation system with engine exhaust gases whilst the exhausts of the hull-mounted diesels – which are routed through the mainmast – are shrouded.

Command and Control: The Type 23s were built at a time when developments in computing technology were driving a move away from centralised combat management system (CMS) computing networks in which consoles, sensors and weapons are all connected to one or more central computers in a 'star'-shaped-architecture. The alternative approach, which has now become commonplace, involves distributing computing power around a local area network under a distributed-architecture. The Royal Navy's transition to the new approach was not straightforward, involving abandonment of the Computer Assisted Command System (CACS) 4 originally intended for the Type 23 design. Its replacement, the fully distributed Outfit DNA(1) took time to develop. It was not until *Westminster* – the eighth Type 23 frigate commissioned in May 1994 – that a full set of DNA(1) hardware was installed. Operational software was delivered in phases from 1995 onwards, with full 'in service' date not achieved until mid-May 1998. The delays to DNA(1)'s introduction meant that earlier members of the class completed without an integrated command system. They could therefore only be deployed to lower-threat areas until the system was retrofitted.[8]

In contrast to later Royal Navy surface combatant designs, the Type 23's operation room/command centre is placed deep in the ship's hull. This has brought the limitations of being a relatively cramped and irregularly shaped space in which to shoehorn the necessary CMS workstations. DNA(1) had twelve operator consoles with full-colour displays, repre-


HMS Lancaster 1992
Type 996 3D surveillance & target indication radar
UAF1 ESM intercept array
GSA8 Sea Archer GFCS
Merlin HM1 helicopter [from 2002]
Type 911 missile FC radar
SCOT SatComm p&s
Type 911 missile FC radar
4.5in Mk 8 D-P gun
Lynx HAS3 helicopter
F229
Type 2031(Z) towed sonar
2 324mm fixed tubes for Stingray torpedoes p&s
DS30B 30mm gun p&s
8 Harpoon SSMs
L A
DLB Sea Gnat chaff/decoy dispensers p&s
32 VL tubes for SeaWolf SAMs
0 10 20 30
METRES
© John Jordan 2020

This picture of *St Albans'* operations room taken in 2006 gives some impression of the rather cramped space it occupies compared with that in more spacious later Royal Navy designs, where the position has typically being shifted upwards into the superstructure. The consoles are those associated with the original DNA(1) CMS, although the original CRT screens have been replaced with flat panels. *(Crown Copyright 2006)*

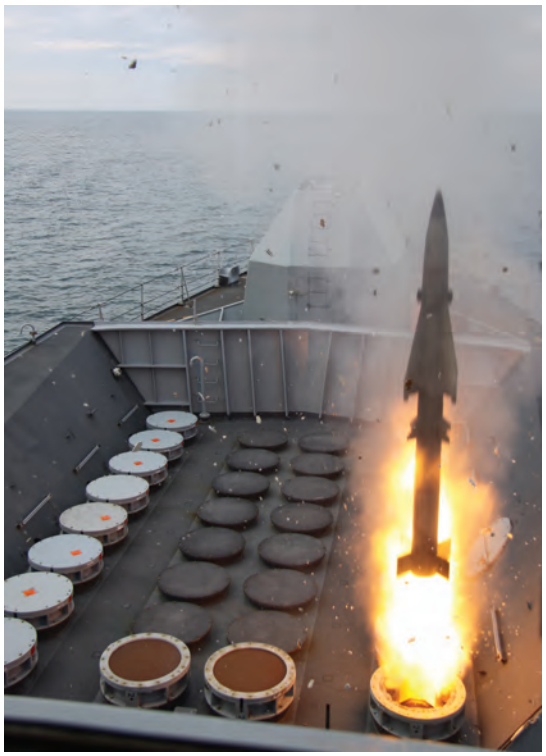
The Merlin HM 1 helicopter – now superseded by the improved Merlin HM 2 variant – was intended to be the Type 23s' main anti-submarine weapon but development delays meant that it lagged behind the frigates' entry into service. This photograph of a Merlin landing on *Westminster's* deck during the course of operations off the Libyan coast during that country's civil war in 2010 gives a good indication of the rotorcraft's considerable size. *(Crown Copyright 2010)*

senting the first time a Royal Navy surface command system utilised common multi-function consoles with colour displays. The system could handle 1,000 tracks and had an encyclopaedic database.

As might be expected, the Type 23s were completed with a comprehensive communications suite, including satellite communications and NATO Link 11. The original radar electronic support measures (RESM) system on earlier members of the class was Outfit UAF 1, which incorporated a series of distinctive pyramid-like antennae towards the top of the forward mast. These arrays were retained when later ships commissioned with the improved Outfit UAT, now fitted to all remaining Royal Navy ships of the class. Four Sea Gnat (Outfit DLB) launchers were specified to dispense chaff and IR decoys. However, it seems the Type 675(2) jammer was never fitted before its withdrawal. Anti-torpedo defence was initially in the hands of the 1950s-era Type 182 towed torpedo decoy.

Sensors and Armament: The significant changes made to the Type 23 throughout its design phase provided a degree of anti-air and anti-surface warfare capability absent from the original Staff Requirements. In spite of this shift, the Type 23 essentially remains an anti-submarine hunter. In addition to the focus on acoustic stealth already discussed, this capacity is provided by a combination of sophisticated sonar systems and an embarked helicopter.

The ability to deploy a cutting-edge sonar suite was the Type 23's original raison d'être. The primary sonar system on completion was the Type 2031Z passive towed array. Used both tactically and for surveillance, it was capable of extremely long-range detection and was reportedly over 500m in length. However, the system was already regarded as approaching obsolescence by the mid-1990s and was not installed in later members of the class. Type 2031Z was paired with Type 2050, a low-frequency bow-mounted sonar developed from the earlier Type 2016. Capable of active and passive operation at



A Sea Wolf missile being fired from *Richmond* during a training exercise in 2013. The GWS 26 MOD 1 VLS variant of Sea Wolf incorporated a booster motor, increasing the c. 3.5 nautical mile (7km) range of the original trainable system to some 5.5 nautical miles (10km). *(Crown Copyright 2013)*

short to medium ranges, it was installed in all sixteen class members and remains fitted to most. The Type 23's operating concept envisaged targets identified by the sonar suite being attacked at long range by a large helicopter equipped with its own sonar and anti-submarine torpedoes. This was the EH101 Merlin. However, deliveries of operational Merlin HM 1 airframes lagged behind Type 23 frigate construction. Consequently, it was not until 2002 that *Lancaster* completed the first operational deployment of the Merlin in the class, earlier class deployments embarking the smaller and less capable Lynx. The Type 23s were also completed with two pairs of fixed 324mm torpedo tubes for close range anti-submarine defence. These use the same Stingray light torpedoes carried by the Merlin and share a common magazine.

As has been seen, most of the Type 23's remaining armament dates from the later stages of the design process and resulted in a far more flexible and inde-

This detailed view of *Lancaster* taken in 2009 shows many of the 'Duke' class's principal sensors. A Type 996 surveillance and target-indication radar is at the top of the forward mast with the antennae for the Outfit UAT radar electronic support measures system below. The rear of the GSA 8 Sea Archer electro-optical director for the Mk 8 4.5in gun is partly hidden by the mast, which also contains the outlet for the diesel generators from the forward auxiliary machine room on its aft face. A Kelvin Hughes Type 1007 navigation radar is on the port-side mast extension above the satellite terminals, which also partly obscure the forward Type 911 Sea Wolf tracker. *(Conrad Waters)*

pendently deployable ship. The addition of the GWS 26 Mod 1 Sea Wolf vertical launch system (VLS) represented a particularly important upgrade. In the class's original configuration, targets would initially be detected by the NATO E/F band (US Navy S band) Type 996 3D surveillance radar atop the forward mast out to ranges of up to 65 nautical miles (120km). This would pass target indication data to the CMS, which would then trigger a Sea Wolf engagement directed by one of the two Type 911 fire-control radar systems. The VL Sea Wolf has a maximum range of c. 10km.

The Type 23's main anti-surface armament comprises two sets of quad packed Harpoon surface-to-surface missiles, backed by the ubiquitous Mk 8 114mm gun. The latter is controlled by a GSA 8 Sea Archer electro-optical director. No close-in weapons system (CIWS) has ever been installed in the class, although sided 30mm gun mountings are provided for defence against asymmetric threats. On first commissioning, these were single DS30B mounts equipped with the Oerlikon KCB cannon.

Other Design Aspects: Beyond the priority attached to anti-submarine warfare, a major driver to the Type 23 design was to reduce crew size by replacing manpower with technology. When the design was finalised, it was intended to operate the frigates with around 145 crew, leaving surplus accommodation for some 40 supernumeraries. However, in a trend common with many current optimally-crewed designs, this had increased to approximately 170 – 15 officers, 50 senior rates and 105 junior rates – when the class started to commission. Accommodation was regarded as being comparatively spacious when the ships first entered service, although it has been subsequently overtaken by the enhancements achieved in more recent designs. As previously mentioned, the Falklands' experience resulted in accommodation being shifted closer to the crew's action stations, with officer cabins located in the bridge superstructure and the majority of ratings being housed on 2 Deck. As completed, senior ratings were allocated a mixture of two, four and six-berth cabins forward, with junior ratings living in four messes aft.

The focus on optimal crewing saw the adoption of new means of working. Contemporary reports suggested that many challenges had to be overcome as new organisational structures were implemented to respond to the challenge. More fundamentally, a decision to reduce stowage capacity in a class intended largely for North Atlantic duties created difficulties when the class deployed globally in the post-Cold War era. Another constraint was a decision not to fit task force command spaces, restricting operational flexibility.

AN EVOLVING ROLE

The delivery of the early Type 23 frigates coincided with the Cold War's end. The resultant swift decline in Russian sea power meant that the primary North Atlantic anti-submarine warfare mission for which the class had been designed largely ceased to have relevance, at least for the time being. International stabilisation operations, often in littoral waters, became the new order of the day. The Type 23s were therefore increasingly pressed into roles far from which they were originally envisaged. More broadly, the post-Cold War 'peace dividend' slowed the class's entry into service and – at least initially – reduced the amount of funding available for intended modifications and upgrades. The same financial backdrop meant that the initial plan to retire them after relatively short service lives when key equipment

Table 3.3.2: TYPE 23 FRIGATE CLASS LIST

SHIP	PENNANT	BUILDER	ORDERED[1]	LAID DOWN	LAUNCHED	COMMISSIONED	PLANNED WITHDRAWAL
Norfolk	F230	Yarrow, Scotstoun	October 1984	14 December 1985	10 July 1987	1 June 1990	Sold to Chile 2005[2]
Marlborough	F233	Swan Hunter, Wallsend	August 1986	22 October 1987	21 January 1989	14 June 1991	Sold to Chile 2005[3]
Argyll	F231	Yarrow, Scotstoun	September 1986	20 March 1987	8 April 1989	31 May 1991	2023
Lancaster	F229	Yarrow, Scotstoun	September 1986	18 December 1987	24 May 1990	1 May 1992	2024
Iron Duke	F234	Yarrow, Scotstoun	July 1988	12 December 1988	2 March 1991	20 May 1993	2025
Monmouth	F235	Yarrow, Scotstoun	July 1988	1 June 1989	23 November 1991	24 September 1993	2026
Montrose	F236	Yarrow, Scotstoun	July 1988	1 November 1989	31 July 1992	2 June 1994	2027
Westminster	F237	Swan Hunter, Wallsend	December 1989	18 January 1991	4 February 1992	3 May 1994	2028
Northumberland	F238	Swan Hunter, Wallsend	December 1989	4 April 1991	4 April 1992	29 November 1994	2029
Richmond	F239	Swan Hunter, Wallsend	December 1989	16 February 1992	6 April 1993	22 June 1995	2030
Somerset	F82	Yarrow, Scotstoun	January 1992	12 October 1992	25 June 1994	20 September 1996	2031
Grafton	F80	Yarrow, Scotstoun	January 1992	13 May 1993	5 November 1994	29 May 1997	Sold to Chile 2005[4]
Sutherland	F81	Yarrow, Scotstoun	January 1992	14 October 1993	9 March 1996	4 July 1997	2032
Kent	F78	Yarrow, Scotstoun	February 1996	16 April 1997	27 May 1998	8 June 2000	2033
Portland	F79	Yarrow, Scotstoun	February 1996	14 January 1998	15 May 1999	3 May 2001	2034
St Albans	F83	Yarrow, Scotstoun	February 1996	18 April 1999	6 May 2000	6 June 2002	2035

Notes:

1. Order dates are approximate – sometimes there is confusion between when the planned order was announced in Parliament and when the actual contract was placed.

2. Recommissioned as *Almirante Cochrane* (FF-05) on 22 November 2006.

3. Recommissioned as *Almirante Condell* (FF-06) on 28 May 2008.

4. Recommissioned as *Almirante Lynch* (FF-07) on 28 March 2007.

became obsolete rather than embark on midlife refits became impossible to sustain. Despite being criticised as being '… designed a little too late and a little too small …' it says much for the qualities of the original design team that the Type 23s have remained effective front-line combatants some 30 years after first entering service.[9]

The early Type 23s were effectively delivered to an interim standard, with the lack of a working CMS until after *Westminster* commissioned having a major impact on early mission taskings. Although *Norfolk* undertook an early deployment to the Far East as part of the Orient 92 Task Group, the class were not assigned to supporting operations in higher threat areas such as the Persian Gulf until after DNA(1) achieved full operational capability in mid-1998. Instead, the class's overseas commitments were largely in comparatively benign environments, such as Atlantic Patrol Taskings North and South. Once full mission capability was achieved, however, the frigates were assigned higher profile roles. Notably both *Marlborough* and *Richmond* provided naval gunfire support during the amphibious assault on the Al Faw peninsula in the course of the 2003 invasion of Iraq. Deployments to the Persian Gulf and Indian Ocean have become a regular feature of Type 23 deployments.

Argyll pictured on her delivery voyage from her builders, Yarrow, in April 1991. Although early deliveries were relatively rapid, the lack of a combat management system (CMS) in early ships meant that they were not able to be deployed in higher-threat environments until the relevant equipment was retrofitted. *(BAE Systems)*

The installation of a fully-functioning CMS in the form of DNA(1) allowed the Type 23s to be deployed to higher-threat areas such as the Persian Gulf. The class participated in the 2003 invasion of Iraq and have become a frequent sight protecting trade in the Indian Ocean and Gulf, where this picture of *Montrose* was taken in January 2020. *(Crown Copyright 2020)*

A decision to de-emphasise Royal Navy anti-submarine warfare capabilities in the post-Cold War era saw three Type 23s sold to Chile in 2005. This is the new *Almirante Cochrane* – the former *Norfolk* – working up under her new owner's flag in June 2007. Note that the Outfit UAF/UAT arrays have been removed from the forward mast. *(Conrad Waters)*

The Type 23s have been subject to a programme of rolling updates that have materially changed their capabilities and appearance. This photograph of *Kent* departing Portsmouth taken in March 2009 when she was largely unchanged from her appearance on first delivery makes an interesting comparison with the chapter's opening 2020 image of her taken in virtually the same location. *(Conrad Waters)*

Meanwhile, the Type 23 class achieved full strength on 6 June 2002 with the commissioning of *St. Albans.* However, two years later, in July 2004, it was announced that three of the class – *Norfolk, Marlborough* and the comparatively recent *Grafton* – would be paid off by March 2006 as 'the potential submarine threat to most future UK operations is likely to be low'.[10] The ships were sold to Chile under a £134m deal signed in September 2005. The reduced emphasis on anti-submarine warfare was also reflected in a decision to replace the obsolescent Type 2031Z sonar array in only eight of the class. This effectively resulted in the other five vessels – the oldest Type 23s remaining in Royal Navy service – being permanently re-roled as general-purpose frigates.

Ironically, the downsizing of the Type 23 fleet and the de-emphasising of the anti-submarine warfare role in some of the remaining ships was implemented only shortly before the re-emergence of Russia and, particularly, its submarine fleet as a potential maritime threat. Moreover, ongoing delays to the Royal Navy's Future Surface Combatant programme – which finally evolved into the Type 26 Global Combat Ship – meant that the Type 23s would inevitably be in the front line in combating this challenge for the foreseeable future. This has seen the anti-submarine configured class members increasingly focused on the protection of (1) the strategic deterrent and (2) the new aircraft carrier task groups as their primary roles, with the remaining ships assigned to independent deployments.

PROGRESSIVE UPGRADES

The original Type 23 design concept was heavily influenced by the high cost of the major mid-life refits performed on the *Leander* class frigates. It was therefore intended that their service lives would be restricted to 18 years. Upgrades were to be restricted to frequent but short and less costly periodic work packages that would maintain existing equipment and support limited technological upgrades. Withdrawal would take place before major items of equipment became obsolete or fell due for replacement. However, this approach fell apart with the ongoing delays experienced by the Future Surface Combatant programme, resulting in a need for more complex refits to allow the class to remain in service far longer than originally envisaged. Fortunately, the fact that the Type 23s had been designed to operate in the harsh conditions experienced in the North

This stern view of *Northumberland* taken during a Middle East deployment in 2008 provides a good view of the body of the ship's Type 2087 sonar, which is located in the port-side stern opening below the flight deck. Type 2087 started to be deployed in the class starting with *Westminster* in 2004. *(Crown Copyright 2008)*

Westminster pictured in the giant Frigate Refit Complex at Devonport in 2009 during one or the progressive upgrades applied to the class *(Crown Copyright 2009)*

Atlantic meant that their hulls could sustain significant life extensions. The main challenge has therefore been renewing or replacing equipment that has reached the end of its intended operating life.

The major work packages undertaken on the Type 23s are sometimes referred to as discrete mid-life refits and major life extension (LIFEX) projects. However – reflecting the original upgrade concept – it is probably more accurate to see this work as part of a broader, ongoing through-life management plan that has been devised for the class. In effect, a continuous rolling programme of refurbishment and modernisation has been implemented to achieve the plan's overall objectives.[11] Individual ships rotate through this programme as they fall due for refit, receiving the latest available equipment and improvements planned for the class at that particular time. For example, the current iteration of the through life management plan has sometimes been referred to as the Type 23 Frigate Capability Sustainment Programme but contains many discrete elements that may, or may not, be undertaken in the same refit. One consequence of this approach is that there have been significant overlaps between the work packages undertaken on particular ships as they move through the upgrade cycle. Different Type 23s – even those assigned to a similar role – will frequently exhibit differences in equipment and capability dependent on precisely when their last upgrade occurred.

The process of upgrading the Type 23s commenced whilst the later class members were still under construction. A major milestone occurred with the commissioning of *Westminster* in 1994, often regarded as the first member of the class to be completed to the definitive operational standard. In addition to the first DNA(1) CMS, she received more powerful Spey SM-1C gas turbines and the Outfit UAT RESM system. Although limited by gearbox constraints, the Spey SM-IC has enabled speeds in excess of 34 knots to be achieved when combined with the use of a stern transom flap and improved underwater paints.[12] In very general terms, early refits focused on retrofitting DNA(1) to earlier members of the class and undertaking a range of relatively minor enhancements. These included replacement of the original 4.5in gun with the Mod 1 mounting (completed from 2001 onwards starting with *Norfolk*). A number of ships were also fitted with handling equipment to operate the new Merlin.

Subsequent upgrade phases have encompassed more significant alterations to the original design, notably installation of the Type 2087 towed array sonar in those ships allocated to anti-submarine duties (from 2004 onwards starting with *Westminster*). Class-wide improvements have included new DS30M 30mm guns (from 2007 starting with *Somerset*); the revamped DNA(2) CMS (from 2010 with *Montrose*); the Type 997 Artisan multifunction radar (from 2015 with *Iron*

Table 3.3.3.

HMS MONTROSE

PRINCIPAL PARTICULARS (AS AT 2018)

Building Information:

Laid Down: 1 November 1989 **Launched:** 31 July 1992 **Commissioned:** 2 June 1994

Builders: Yarrow (Shipbuilders) Limited, Scotstoun. Last refit at Babcock International's Frigate Refit Complex Devonport 2014–17.

Dimensions:

Displacement: c. 4,800 tons full load displacement.

Overall Hull Dimensions: 133.0m x 16.1m x 5.5+ m (7.3+ m sonar). Waterline length is 122.0m

Equipment:

Missiles: 32-cell VLS for Sea Ceptor surface-to-air missiles.
2 x quadruple launchers for Harpoon surface-to-surface missiles.

Main Guns: 1 x 114mm Mk 8 Mod. 1 gun, 2 x 30mm DS30M remotely-controlled cannon. Light machine guns.

Torpedo Tubes: 2 x twin 324mm for Stingray light torpedoes.

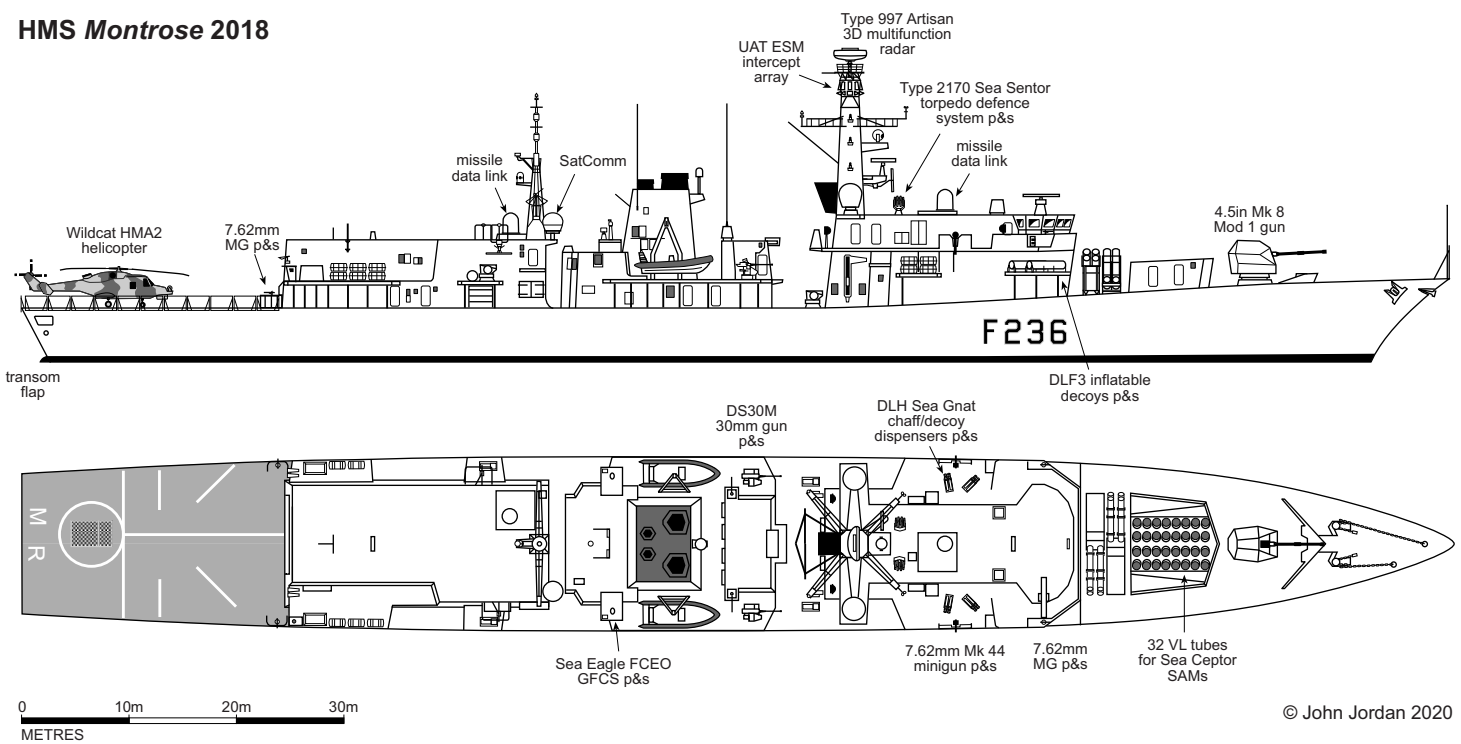
Countermeasures: 4 x Sea Gnat (Outfit DLH) decoy launchers, Type 2170 Sea Sentor SSTD.

Aircraft: Flight deck and hangar for one medium-sized helicopter. Wildcat HMA 2 currently embarked.

Principal Sensors: Type 997 Artisan multifunction radar. Navigation radar. Type 2050 bow-mounted sonar.

Combat System: Outfit DNA(2) CMS. Outfit UAT RESM. Hammerhead CESM. Comprehensive Communications including NATO Link 11.

Propulsion System as Completed



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HMS PORTLAND (AS REFITTED END–2020)

Building Information:

Laid Down: 14 January 1998 **Launched:** 15 May 1999 **Commissioned:** 3 May 2001

Builders: Yarrow (Shipbuilders) Limited, Scotstoun. Last refit at Babcock International's Frigate Refit Complex Devonport 2018–20.

Equipment (As above with the following exceptions):

Principal Sensors: Type 997 Artisan multifunction radar. Navigation radar. Type 2150 bow-mounted sonar. Type 2087 variable-depth towed array.

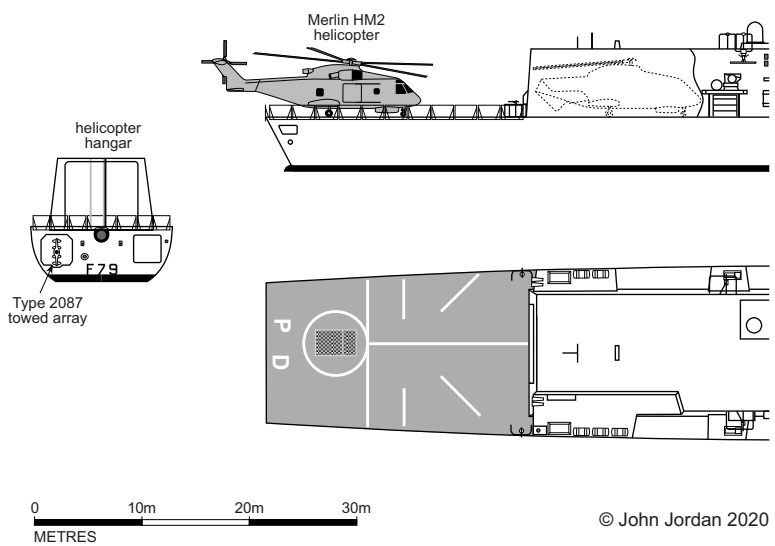
Aircraft: Flight deck and hangar for one medium-sized helicopter. Merlin HM 2 usually embarked.

Propulsion Systems:

Machinery: CODLAG. 4 x Rolls-Royce MTU 12V 4000 M53B diesel generators each rated at 1. 65MW provide power for 2 x 1.5MW GE electric motors and hotel services. 2 x Rolls-Royce Spey SM-1C gas turbines each rated at c. 19.5MW for sprint speed. Twin shafts.

Speed: 32+ knots. Endurance is 7,800 nautical miles at 15 knots.

HMS *Portland* 2020



Duke); and the Sea Ceptor missile system (from 2017 with *Argyll*).

Although Type 23 refits have previously taken place in other locations, class upgrades are increasingly being focused on the Frigate Refit Complex at Devonport. Operated by Babcock International, the massive facility's three covered berths are currently heavily committed to the next stage of class life extension work that encompasses a power generation and machinery controls update (PGMU). Scheduled to be performed on the eleven youngest Type 23s, the PGMU will replace the existing, life-expired diesel generators with new 1.65MW MTU12V 4000 M53B units. Upgrades will also be carried out to relevant aspects of the machinery controls and surveillance (platform management) system and to HPSW cooling arrangements. As well as dealing with equipment obsolescence, the PGMU will restore a margin of electrical power capacity.[13] *Richmond* was the first ship to embark on the upgrade, returning to sea for trials early in 2020.

The cumulative impact of the progressive updates performed on the Type 23s to date are reflected in Table 3.3.3 and its associated drawings. One of the most visually apparent changes is the substitution of the new Sea Ceptor missile system and the associated Type 977 Artisan E/F band multifunction radar for the original combination of Type 996 surveillance and Type 911 fire-control radars with the Sea Wolf missile. Sea Ceptor has a longer, c. 25km range than its predecessor, providing local air defence coverage. Equipped with an active seeker, it can be fed target information obtained by Artisan via data link until the final stages of an engagement. The need for separate fire-control radars is dispensed with and many more targets can be engaged simultaneously.

Other improvements to weapons systems include the replacement of the original 4.5in Mk 8 gun with the improved Mod 1 variant. Key changes included adoption of a new, stealthy gun house and the replacement of hydraulic systems with electric motors to increase reliability and reduce weight. The original single 30mm DS30B mounts have also been replaced. The substitute DS30M Automated Small Calibre Gun (ASCG) mountings incorporate a 30mm Bushmaster II cannon and use an off-mount Chess Dynamics Sea Eagle FCEO electro-optical director. In contrast to the earlier weapons, they are normally remotely operated. A further change has been an increase in the outfit of light weapons for further defence against asymmetric threats. Most

ships now have dedicated positions for at least two 7.62mm Miniguns and four General Purpose Machine Guns.[14]

Internally, the class's CMS has been subject to a number of significant upgrades; first with the DNA(2) iteration of the original system and more recently with installation of BAE Systems' Shared Infrastructure platform.[15] The latter allows software from multiple combat system technology suppliers to be hosted on common hardware, reducing cost and increasing flexibility. Electronic warfare systems have also been steadily enhanced. Additional countermeasures include the Type 2170 (Sea Sentor) Surface Ship Torpedo Defence System and Outfit DLF 3 inflatable offboard decoys, whilst Sea Gnat has been upgraded to Outfit DLH standard, with the ability to fire Siren radiating decoys. The Outfit UAT RESM – which addressed processor capacity issues in the original Outfit UAF-1 – has been subject to a spiral of ongoing improvements. Details of communications electronic support measures (CESM) capabilities are shrouded in more secrecy. However, it is known that at least some of the class have been fitted with an 'off the shelf' system known as Hammerhead supplied by Babcock in conjunction with US electronic warfare expert Argon ST under a contract announced in 2013. This builds on Argon ST's Lighthouse system architecture used in other CESM fits. CESM equipment is probably only installed on a mission-specific basis.

The eight Type 23s that remain optimised for anti-submarine warfare are all equipped with Type 2087 sonar, a variable-depth towed array capable of operating in both passive and active modes. It is marketed internationally as the Thales CAPTAS-4 and is now used by a number of other navies, including by France and Italy in their FREMM frigates. The anti-submarine configured Type 23s will also all receive Ultra Electronics' bow-mounted Type 2150 sonar in place of the original Type 2050 system. *Portland* was the first of the class to be equipped with Type 2150 during her 2018-20 refit. The anti-submarine Type 23s also have priority for deployment with the latest Merlin HM 2 variant; the older general purpose vessels usually embarking the smaller, anti-surface warfare optimised Wildcat HMA 2 helicopter.

CHILE'S TYPE 23S

The three Type 23s sold to Chile were initially refitted in Portsmouth before delivery, commis-

Montrose – seen here in three images taken in the course of 2018 – provides a good external representation of the class's most recent iteration, albeit without the towed array fitted to those class members focused on the anti-submarine role. Points of note include the Sea Ceptor 'mushroom' covers in place of the previous Sea Wolf and the deletion of separate fire control radars in favour of smaller digital uplink domes. The removal of the Type 911 fire-control radars has also permitted the baffles previously fitted to counter the equipment's radar signature to be dispensed with. *(Crown Copyright 2018)*

Kent pictured replenishing from the US Navy's fast combat support ship *Supply* (T-AOE-6) in the Barents Sea on 3 May 2020. The more recent Type 23s will serve well into the 2030s in a testament to their original design team's success. *(US Navy)*

sioning between 2006 and 2008. After more than a decade of service with their new owners, they also require major upgrades. These are being performed by local company ASMAR in conjunction with Lockheed Martin Canada, which was selected to integrate its CMS 330 combat management system into the vessels under a contract announced in May 2017. CMS 330 – originally developed for the Canadian *Halifax* class frigate mid-life upgrades – will operate in conjunction with a Hensoldt TRS-4D multifunction radar and Sea Ceptor surface-to-air missiles. The modernisation will also encompass a series of other upgrades, including the provision of Link 16 and Link 22 communications. *Almirante Cochrane* (ex-*Norfolk*) was the first to complete the process in October 2019. Chile has also procured Type 2087 towed arrays under a separate contract and is said to be interested in installing the new Type 2150 sonar.

CONCLUSION

The rolling series of upgrades applied to the Type 23s has meant that they remain well-suited to front-line operations in similar fashion, for example, to the US Navy's *Arleigh Burke* (DDG-51) class destroyer design of broadly similar vintage. They continue to

The policy of ongoing modernisation applied to the Type 23s means that they remain well-suited to front-line operations in similar fashion to the US Navy *Arleigh Burke* (DDG-51) class from the same era. They will have a particularly important role supporting the Royal Navy's new carrier task groups in the anti-submarine warfare role. Here *Northumberland* (second from top) is pictured with *Queen Elizabeth*, *Tideforce* and a mixture of RN and USN surface escorts during the WESTLANT 19 deployment. *(Crown Copyright 2018)*

be deployed to high-threat areas, with both *Argyll* and *Montrose* operating in the Persian Gulf as of mid-2020 as part of the 'Kipion' maritime security mission. *Montrose* is currently the guinea pig for a new form of extended forward deployment being considered for the navy's major surface combatants. Departing Devonport in October 2018, she undertook a series of defence diplomacy operations in the Caribbean, South Pacific and Far East before arriving at the Royal Navy's new support facility, HMS *Jufair*, in Bahrain. It is intended that *Montrose* will remain based in the region until returning to home waters in 2022 or 2023. She has adopted a dual port/starboard crewing concept, with crews being swapped by air approximately every four months to allow her to remain on station for the extended period.

Maintaining the class's capabilities has, however, come at some cost. The need to perform significant life extension is putting a heavy strain on overall availability. Around half the class are currently either in refit or in the course of post-refit work-up. There are some indications that reliance on the Devonport Frigate Refit Complex has resulted in something of a bottleneck, with heavy use of the three-berth facility resulting in an inevitable knock-on effect if unexpected complications delay the completion of any one work package.

Current plans envisage the five oldest, general purpose-roled Type 23s being retired at annual intervals between 2023 and 2027, being replaced by the new Type 31 light frigates. This programme is already running behind schedule but, as yet, there have been no indications Type 23 out-of-service dates will be extended as a result. The later, anti-submarine optimised Type 23s are due to decommission at a rate of one p.a. from 2028 onwards as the new Type 26 Global Surface Combatants start to enter service. *St Albans* is scheduled to be the last Type 23 when she retires in 2035, some 45 years after *Norfolk* first joined the fleet.

Much of the equipment specified for the Type 26s will be common to that installed in the Type 23 class's current iteration. Indeed, some will be 'donated' directly to new-build Type 26s after the older ships are withdrawn. The Type 23s' ability to evolve to an ever-changing environment through the acceptance of new equipment and systems has been one of the original design team's major successes in spite of the significant cost-constraints they laboured under when first drafting the 'Duke' class design.

Notes

1. D K Brown and George Moore, *Rebuilding the Royal Navy: Warship design since 1945* (London: Chatham Publishing, 2003), pp.110–11. David K Brown, who retired in 1988 as Deputy Chief Naval Architect, had intimate knowledge of the Type 23 programme and its predecessors.

2. See M B Hawke, Cdr. N J Mills-Hicks, Cdr. W B Harris, J R Scott, L Shepherd & Cdr. J P Bullard, 'The Type 23 Frigate', *Journal of Naval Engineering,* Volume 29 – Book 1 (Bath: Sea Systems Controllerate, 1984), pp.15–26. Their account of the initial design process for the Type 23 frigate is broadly consistent with that of Brown & Moore but differs in some details.

3. The Type 23 designation was re-allocated from a previous abortive design and the type designations therefore fell out of sequence.

4. The Type 23 was intended to operate the planned Anglo-Italian EH101 helicopter – now named the Merlin in British service – but the project was still at the development stage in 1982. It was therefore considered sensible to design the frigates to operate the existing Sea King in case the new helicopter programme was unsuccessful.

5. See Comptroller and Auditor General, *Ministry of Defence: Design and Procurement of Warships* (London: HMSO, 1985), p.9. This report also refers to Thornycroft Giles and Associates' unsuccessful attempts to put forward their Sirius 90 design concept – the 'short, fat frigate' – as an alternative to the more conventional Type 23 design. Their efforts sparked an ongoing debate that was only concluded by an independent Lloyds of London inquiry that found the proposal had little merit.

6. In essence, as the ship sinks deeper into the water whether through additional equipment or action damage the waterplane area increases.

7. See Cdr. Kenneth J McKenzie & Constructor Cdr. Nigel Moores, 'The Type 23 Frigate-Britain's ASW Frigate for the Nineties', *Naval Engineers Journal,* May 1992 (Alexandria VA: American Society of Naval Engineers, 1992); pp.228–35.

8. For the broader context and further detail, see Peter Marland, 'Post-War AIO Command Systems in the Royal Navy', *Warship 2016* (London: Conway, 1996), pp.76–98. *Westminster* was actually the seventh Type 23 to commission but she was ordered and laid down after *Montrose,* which entered service some three weeks later.

9. See *Type 23 Duke Class,* a report published by Forecast International archived in December 2005 and available by searching the Forecast International archive at: https://www.forecastinternational.com/archive/

10. The Secretary of State for Defence (Mr. Geoffrey Hoon), *Hansard*, HC Deb 21 July 2004 vol. 424 cc343–70.

11. See James Heappey, Type 23 Frigates, *UK Parliament: Written Answer*, 13 January 2020 HC 1302, 'The Type 23 Frigate class is continually being updated and upgraded to meet new threats or to replace obsolete technology. This is achieved via a Through Life Management Plan rather than any singular Major Life Extension programme.'

12. *Sutherland* reportedly holds the speed record for the 'Duke' class, recording 34.4 knots in trial conditions in November 2008. Although sources differ, it seems that the SM-1A Spey gas turbines fitted to earlier members of the class have not been replaced.

13. For further detail, see the paper *T23 Frigate Power Generation and Machinery Controls Update (PGMU) – Let the trials commence* presented by T D Peacock of Babcock International at the 8th Engine As A Weapon International Symposium held in London in July 2019 and available by searching the web. The paper refers to the Type 23s having reached the maximum limit of their growth margin as they approached the date of their original planned service life. It also mentions constraints arising from the provision of insufficient cooling capacity for operations in warmer waters in what was originally a North Atlantic design, resulting in generators running at only around 75 percent of their designed capacity in such conditions. These problems partly reflect a conscious decision during the design phase to limit electrical and cooling systems to a 10 percent design margin with zero life margin compared with margins of, respectively, 25 percent and 20 percent in previous classes. This clearly illustrates the potential for false economies in an unduly cost-focused design.

14. Photographs of some members of the class show additional positions. The Royal Navy also uses .50 (12.7mm) calibre Browning heavy machine guns and these are likely installed in lieu of some of the 7.62mm general purpose machine guns in higher-threat environments.

15. DNA(2) is a less bespoke system than DNA(1), taking advantage both of commercial off the shelf equipment and software developed for the CMS(1) system installed in the Type 45 destroyer.

4.1 TECHNOLOGICAL REVIEW

WORLD NAVAL AVIATION

A Review of Recent Developments

Author:
David Hobbs

This year's regular review of world naval aviation includes an examination of studies that might lead to significant changes in future US Navy aircraft carrier procurement. It also looks in some detail at current naval air training, using US Navy and British Royal Navy experience as its references. However, no review of the year would be complete without first looking briefly at the COVID-19 pandemic and its impact on aircraft carrier deployments.

A F/A-18F Super Hornet, assigned to the 'Black Knights' of Strike Fighter Squadron (VFA) 154, launches from the flight deck of the aircraft carrier *Theodore Roosevelt* (CVN-71) on 18 March 2020 during operations in the Philippine Sea. The aircraft carrier was at the epicentre of a major COVID-19 outbreak by the end of the month. *(US Navy)*

By far the most prominent outbreak of COVID-19 to impact fleets worldwide has been that suffered by the US Navy aircraft carrier *Theodore Roosevelt* (CVN-71). In late March 2020 the carrier arrived in Guam Naval Base in the grip of a viral outbreak contracted following a port visit in Vietnam. With cases rising rapidly, *Roosevelt*'s commanding officer, Captain Brett Crozier USN, emailed Pacific Fleet leadership asking for greater resources to help safely quarantine his ship's company, ending, 'We are not at war. Sailors do not need to die. If we do not act now, we are failing to properly take care of our most trusted asset – our Sailors.' The US Navy's Chief of Naval Operations (CNO) – Admiral Michael Gilday – subsequently told press that Crozier's email had 'detailed a requirement for a faster pace than the chain of command had anticipated … to get people off the ship'. The majority of the carrier's crew were moved ashore into base accommodation or local hotels over following days but key personnel remained on board to run the two nuclear reactors and stand by as fire-fighting or damage control parties.

However, events escalated. Acting Secretary of the Navy – Thomas Modly – told reporters on 2 April that Captain Crozier had shown 'extremely poor judgment' in sending his email through an unclassified network and had, therefore, been relieved of his command. US Navy Vice-CNO, Admiral Robert Burke, was tasked with conducting an investigation to determine what factors might have contributed to

the breakdown in the reporting chain. Following reports that thousands of sailors cheered Captain Crozier as he left the ship, Modly made a surprise visit to Guam on 6 April during which he told *Roosevelt* sailors that, in his opinion, Crozier's email could have been a 'serious violation of the Uniformed Code of Military Justice'. He added that if Crozier thought information would not go public, he was 'too naive or stupid' to command the carrier. On his return, Modly faced growing criticism perhaps best typified by the remarks of House Armed Services Committee (HASC) chairman, Adam Smith, who was reported as saying that Modly had lost his ability to effectively lead the service once he made his speech aboard *Roosevelt* denigrating the ship's former commanding officer. Modly first apologised to Captain Crozier and the ship's company and subsequently resigned on 7 April. He was temporarily replaced by James E McPherson, a former US Navy lawyer and Under Secretary of the Army.

Ultimately, over a thousand of *Roosevelt*'s crew tested positive for COVID-19, one of whom sadly died. The ship's company began to move back on board from 29 April onwards, with the ship finally returning to sea on 21 May. Admiral Burke's initial enquiry into the circumstances of the leak, agreed by the CNO and the new Acting Secretary, reportedly called for Crozier to be re-instated. However, a more comprehensive investigation by Admiral Burke demanded by Defense Secretary Mark Esper reversed this recommendation on the basis that the broader response to the COVID-19 outbreak in *Roosevelt* was inadequate.[1]

Meanwhile, on 8 April 2020 the French *Marine Nationale* reported that the aircraft carrier *Charles de Gaulle* had around forty sailors showing symptoms consistent with COVD-19 whilst undertaking exercises in the North Atlantic. The ship cut short its deployment and returned to its home port at Toulon after disembarking its air wing on 11 April but infections steadily rose, ultimately totalling as many as 1,046 or over half the total 1,760-strong crew.[2] Sailors had been isolated as far as possible and additional precautions taken but, as elsewhere, a high level of asymptomatic cases was a major complicating factor. The impact of COVID-19 on both aircraft carrier and wider naval operations is likely to continue for some time to come, whilst vulnerabilities exposed by the disease could have wider ramifications.

The French aircraft carrier *Charles de Gaulle* entering Brest harbour in overcast weather on the rather inauspicious date of Friday 13 March 2020. The visit to the city accelerated a subsequent outbreak of COVID-19 on board the ship that cut short a training deployment to the North Atlantic and saw over a thousand crew members infected with the virus. *(Bruno Huriet)*

AIRCRAFT CARRIERS

The FY2018 National Defense Authorization Act required the US Navy to achieve a fleet of 355 warships in line with the 2016 Force Structure Assessment (FSA). Work on a new Integrated Naval Force Structure Assessment (INFSA) is currently underway against a background where available funding is unlikely to allow this target to be achieved on the basis of the current force structure. The Navy Department believes that INFSA 'could result in a once-in-a-generation change in … the mix of ships that make up the Navy', shifting the fleet to 'a more distributed architecture that includes a smaller proportion of larger ships, an increased proportion of smaller ships and a newly created category of large unmanned surface vessels (USVs)'.[3]

The size and nature of the US Navy's aircraft carrier force, as well as their associated air wings, is inevitably under examination. There have been reports that an internal Defense Department study has called for a fleet of just nine carriers, two fewer than the current level and three below the 2016 FSA target.[4] Former Acting Secretary Modly also commissioned a study – known as the Future Carrier 2030 Task Force (FC-2030) – before his departure to examine the issue. Due to report towards the end of 2020, it was to benefit from input from both US Navy and US Marine Corps leaders on integrated naval force and operating approaches, including the 'in vogue' distributed maritime operations (DMO) and expeditionary advance base operations (EABO) concepts. FC-2030 was to be overseen by an executive panel chaired by former Senator and Navy Secretary John Warner and including other veteran administrators and politicians described as 'thought leaders who have previously contributed to large changes in maritime defence strategies and programmes'.

Modly stated when launching the study that the long term challenges facing the United States and the world would 'demand … hard choices'. With one *Ford* class aircraft carrier completed, though not yet operational, and three more under contract, he considered there was a good opportunity to take

The US Navy's latest aircraft carrier *Gerald R. Ford* (CVN-78) returned to sea in October 2019 after completion of an extended maintenance period following her original trials. Three other members of the class are under contract but a debate is currently underway as to what might follow them. *(US Navy)*

time to re-imagine what comes next, carefully considering cost, survivability and the requirement to sustain the industrial base which employed 57,000 skilled people on aircraft carrier construction in 2020. FC-2030 would consider alternative aircraft carrier ideas and, in subsequent discussions with journalists, Modly said he sought options 'from a clean sheet perspective'. Studies into smaller carriers are not new but were to be re-examined alongside another US Navy study looking at what future carrier air wings could look like after 2030. Modly also said it might be possible for the INFSA and FC-2030 to work in tandem 'to find an avenue that would allow for a different kind of aircraft carrier without wrecking the industrial base'. His comments seem to indicate a belief that if industrial needs could be met by increased nuclear submarine procurement, savings from curtailing construction of nuclear-powered carriers could be a very effective way of growing the fleet within a 'flat-line' budget.

Modly's departure and his temporary replacement as Acting Navy Secretary by James McPherson resulted in FC-2030 being scrapped in mid-May 2020 in favour of broader Defense Department studies into force structure requirements. Moreover, new permanent Navy Secretary Kenneth Braithwaite – who assumed office at the end of May – has also expressed support for the *Ford* class design. Nevertheless, the future of the US Navy's carrier force remains firmly in the spotlight. It seems that the need for sea-based air power is not being questioned. However, its scope and structure – and the most affordable and effective way of deploying it in the decades after 2030 as part of a larger but very different fleet based on DMO – appears to be under considerable scrutiny. Nuclear-powered carriers and their large air wings do have significant advantages. They can cross the world's oceans at high speed and spend considerable periods of time at sea but their disadvantages include very high build and running costs, the latter inflated by their large ships' companies. The fact that a nuclear-powered carrier, itself, does not need to be constantly refuelled at sea is negated by the requirement to replenish aviation fuel, air weapons, logistics and food for the ships'

company frequently while at sea. Other ships in the battle group also need to be refuelled. For a fraction of a nuclear-powered carrier's build and through-life cost, the British *Queen Elizabeth* class carrier offers an air group of thirty-six F-35s plus squadrons of airborne surveillance and control, anti-submarine and assault helicopters. Moreover, it is known that the Royal Navy design could be built from the outset with catapults and arrester wires and would, therefore, be capable of operating any aircraft in the American carrier-capable inventory.

Meanwhile, in October 2019, the *Gerald R. Ford* (CVN-78) returned to sea after a 15-month post shakedown trials maintenance period in Newport News shipyard. By March 2020 she had successfully completed flight deck and carrier air traffic control centre certification inspections, having spent 32 days at sea during which there were 1,352 catapult launches and arrested landings. Further sea-time will bring the carrier closer to a declaration of operational capability. However, with her deck accepted, she is being used for pilot carrier qualifications (CQ) for operational types and T-45C Goshawk trainers. Early problems with the electro-magnetic aircraft launch system, EMALS, and advanced arrester gear, AAG, have seemingly been resolved although there may still be durability issues with the former. The advanced weapons elevators continue to be a problem, however. By April 2020 Newport News Shipbuilding had only completed and handed over five of the ship's eleven elevators, the latest one fixed being the first that goes all the way from the magazines to the to the flight deck. This was lower stage elevator 5, which provides access to the after magazine group. Lower stage elevator 1, which gives access to the forward magazines, was expected to be handed over by the end of 2020. With access between both magazine groups and the flight deck likely to be achieved by 2021 the ship can move a significant step further towards operational capability.

In January 2020 the US Navy announced that the fourth *Ford* class carrier, CVN-81, is to be named *Doris Miller* after the first black American to be awarded the Navy Cross. The other ships on contract are *John F. Kennedy* (CVN-79) and *Enterprise* (CVN-80). The former commenced floating out on 29 October 2019 prior to a formal christening ceremony on 7 December.

For the United Kingdom, the last twelve months have brought significant progress in the restoration of a carrier strike capability. Both *Queen Elizabeth* and *Prince of Wales* are now based in Portsmouth following the latter's commissioning on 10 December 2019. COVID-19 permitting, *Queen Elizabeth* is due to carry out an operational readiness inspection late in 2020. She is then due to carry out her first operational deployment in 2021, deploying east of Suez with a tailored air group (TAG) scheduled to include both British and US Marine Corps F-35B strike fighters together with Royal Navy surveillance, anti-submarine and commando-assault helicopters. 809 Naval Air Squadron (NAS), the first Royal Navy squadron to be equipped with the F-35B, is also expected to start to form in 2021. Under present plans, it will be commissioned in 2023 when the F-35B achieves full operational capability in British service.

The long and complicated process of floating the new carrier *John F. Kennedy* (CVN-79) out of its building dock commenced on 29 October 2019 when the dock was flooded up. The ship was subsequently christened by Caroline Kennedy, President John F. Kennedy's daughter, on 7 December 2019 prior to her finally departing the dock on the 17th of that month. *(Huntington Ingalls Industries)*

The two carriers give the United Kingdom the continuous means to deploy an independent, affordable task force across the world's oceans containing a credible mix of strike fighters, specialised helicopters and amphibious Royal Marine commando teams. The F-35Bs, particularly, give the Royal Navy an unprecedented capability for distributed operations. Their systems have been described in previous editions of *Seaforth World Naval Review.* However, it is worth emphasising that even a single F-35B operating from *Queen Elizabeth* has enormous computing power and can use its electronic warfare capability to suppress enemy defences whilst downloading sensor information to other platforms in real time. Data fusion allows the pilot to engage enemy missiles and their launch platforms using his own missiles or those from ships of the task force closer to the threat. The F-35B is an outstanding intelligence, surveillance and reconnaissance platform in its own right, contributing data to three-dimensional task force situational awareness even whilst carrying out a strike or fighter mission.

The *Queen Elizabeth* class has proved to be an innovative and effective design with lower build and through-life costs than any comparable warship. In its early stages, the author was critical both of the class's – and of the F-35B's – slow design maturation. However, it is clear that they have capabilities

Both Royal Navy carriers – *Queen Elizabeth* and *Prince of Wales* – are now based in Portsmouth following the latter's commissioning on 10 December 2019. *Prince of Wales* arrived at Portsmouth in September 2019 after completion of initial sea trials; this photograph was taken on 4 December 2019 when both carriers could be seen alongside at the base for the first time following her sister's return from operational testing with F-35B Lightning II strike fighters off the east coast of the United States. *(Crown Copyright 2019)*

The latest Japanese defence budget allocates funds to commence the process of modifying the two *Izumo* (DDH-183) class 'destroyers' to operate fixed wing STOVL F-35B aircraft. Modifications will include application of a thermal layer to the flight deck around the landing area and the relocation of the forward Phalanx close-in weapons system. *(JMSDF)*

beyond anything the Royal Navy has deployed before. They will attract world attention, providing a tangible demonstration of national will and capability to protect and project national influence and interest, to deter aggression and uphold the international rule of law.

One example of the carriers' use in defence diplomacy was provided in November 2019 when leaders of the Royal Navy, US Navy and Japanese Maritime Self-Defence Force (JMSDF) met on board *Queen Elizabeth* off Annapolis for trilateral discussions. Admiral Tony Radakin, the Royal Navy's First Sea Lord, told reporters that 'alliances such as this are vital for protecting the freedoms of the international community'. The FY2020 Japanese defence budget allocates 3.1bn Japanese yen (c. US$28m) for F-35B-specific modifications to the helicopter-carrying destroyer *Izumo* (DDH-183). These include the application of a thermal layer to the flight deck around the landing area and the relocation of the forward Phalanx close-in weapons system. This sum is unlikely to cover the installation of the Automated Logistics Information System (ALIS), secure data transfer and briefing facilities which will have to be installed before F-35s can be embarked. Her sister-ship *Kaga* is to be similarly modified in due course. The

The Chinese People's Liberation Army Navy aviation capabilities took a major leap forward with the commissioning of the first indigenously-built aircraft carrier, *Shandong*, at a ceremony at the Sanya naval base on Hainan Island on 17 December 2019. *(Feng Kaixuan/China Military Online)*

Japanese decision to operate embarked F-35Bs has re-started discussion of the merits of fixed wing naval aviation in Australia, especially as several analysts have stressed the strategic need for further growth in defence spending in response to China's increasing military strength. For example, Malcolm Davis of the Australian Strategic Policy Institute has written that a third LHD-type amphibious assault ship with a wing of between twelve and sixteen F-35Bs supported by a larger fleet of destroyers and frigates 'is an option that should be on the agenda in any force structure debate'.[5]

China's second aircraft carrier – the indigenously built *Shandong* – completed her sea trials towards the end of 2019. She was commissioned on 17 December of that year, subsequently sailing through the Taiwan Strait on her first operational voyage. The older *Liaoning* has also been active following completion of a refit early in 2019, making several deployments into the Pacific via the Miyako Strait near Okinawa. A recent programme on a Chinese state television channel claimed that the People's Liberation Army Navy (PLAN) intended to build ten aircraft carriers by 2049, the 100th anniversary of the Chinese Communist party taking power.

Russia's only aircraft carrier, *Admiral Kuznetsov*, continues to be plagued by misfortunes. In December 2019 a fire broke out apparently during welding work in a machinery space when sparks fell into a hold containing fuel. There were several casualties. The ship's refit, due to be completed in 2021, had already been delayed when the dry dock in which work was previously being carried out sank and a crane crashed onto her flight deck.

PROGRESS WITH CARRIER-BORNE AIRCRAFT

Planned US Navy aviation procurement is summarised in Table 4.1.1. Future Year Defense Program (FYDP) projections for the next five years show a marked decline in acquisition numbers compared with previous plans. Notably, the navy is to cease F/A-18E/F Super Hornet production after FY2021, cutting a further multi-year buy for thirty-six previously planned for FY2022-24. Navy acqui-

An F/A-18F Super Hornet, assigned to the 'Knighthawks' of Strike Fighter Squadron (VFA) 136, prepares to launch from the flight deck of the aircraft carrier *Harry S. Truman* (CVN-75) in the Arabian Sea on 21 February 2020. The US Navy plans to end procurement of Super Hornets after FY2021 to concentrate resources on service life modifications of existing airframes. *(US Navy)*

TABLE 4.1.1: US NAVY PLANNED AIRCRAFT PROCUREMENT: FY2020-FY2025

TYPE	MISSION	FY2020 AUTHORISED[1]	FY2021 REQUESTED	FY2022 PLANNED	FY2023 PLANNED	FY2024 PLANNED	FY2025 PLANNED	FYDP PLANNED[2]
Fixed Wing (Carrier Based)								
F-35B Lightning II JSF	Strike Fighter (STOVL)	16 (10)	10	17	20	20	20	**87 (82)**
F-35C Lightning II JSF	Strike Fighter (CV)	20 (20)	21	20	26	26	28	**121 (120)**
FA-18E/F Super Hornet	Strike Fighter (CV)	24 (24)	24	0	0	0	0	**24 (84)**
E-2D Advanced Hawkeye	Surveillance/Control	6 (4)	4	5	5	0	0	**14 (18)**
Fixed Wing (Land Based)								
P-8A Poseidon	Maritime Patrol	9 (6)	0	0	0	0	0	**0 (6)**
KC-130J Hercules	Tanker	3 (3)	5	5	5	3	0	**18 (21)**
UC-12W Huron	Transport	1 (0)	0	0	0	0	0	**0 (0)**
T-44 Replacement[3]	Training	0 (0)	0	0	10	20	20	**50 (30)**
F-5 Tiger II[4]	Training	22 (22)	0	0	0	0	0	**0 (22)**
Rotary Wing								
VH-92A	Presidential Transport	6 (6)	5	0	0	0	0	**5 (11)**
CH-53K King Stallion	Heavy-Lift	6 (6)	7	11	12	18	23	**71 (74)**
C/MV-22B 22 Osprey	Transport	14 (10)	9	13	1	1	0	**24 (42)**
TH-73A[5]	Training	32 (32)	36	36	26	0	0	**98 (109)**
Unmanned Aerial Vehicles								
MQ-25 Stingray	Refuelling	0 (0)	0	0	4	4	4	**12 (8)**
MQ-4C Triton	Maritime Patrol	2(2)	0	0	4	4	5	**13 (17)**
MQ-9A Reaper	Surveillance/Strike	2 (0)	0	0	0	0	0	**0 (0)**
Totals:		**163 (145)**	**121**	**107**	**113**	**96**	**100**	**537 (644)**

Notes:

1. FY2020 authorised numbers reflect numbers actually funded in the Consolidated Appropriations Act signed into law on 20.12.2019; figures in brackets reflect aircraft numbers set out in the Trump Administration's Presidential Budget Request of 11.03.2019 As is frequently the case, the US Congress added material numbers of aircraft over the original request.

2. FYDP (Future Years Defense Program) for 2021–5 as at time of FY2021 Presidential Budget Request with last year's FYDP numbers for FY2020–4 in brackets. The overall trend is a continued marked downturn in planned procurement, particularly of frontline aircraft.

3. Refers to replacement of the T-44 Pegasus (Beechcraft King Air series) twin-engine turboprop trainer.

4. Refers to acquisition of surplus F-5 aircraft from Switzerland for refurbishment to act as 'aggressor squadron' aircraft in the combat training role.

5. Refers to the Leonardo AW119 variant selected to replace the TH-57 Sea Ranger (Bell 206 series) training helicopter.

sition chief James Geurts briefed a HASC sub-committee meeting in March 2020 that the change was not made to save money but rather to allow Boeing to convert its production line from building new aircraft to carrying out service life modifications (SLMs) at the rate of forty per year. Every airframe passing through the SLM process has thousands of flying hours added. Aircraft now entering the programme are also being upgraded to Block III configuration. A transfer of skill from manufacture to assembly is required; the same workforce cannot do both and SLM has been given the greater priority.

Asked about the US Navy's fighter shortfall, Geurts said that it was about forty-nine aircraft short of a c. 800 requirement in 2020. However, as F-35Cs and SLM F/A-18E/Fs reach the fleet, the shortfall is expected to disappear by 2029. He believed this to be a manageable risk, especially as measures begun last year have improved mission-capable numbers. The US Marine Corps (USMC) has no shortfall after the Navy transferred its legacy F/A-18C/D Hornets to it. Its Deputy Commandant for Aviation, Lieutenant General Steven Rudder, told the sub-committee that the Corps' biggest challenge was the rolling transition to the F-35B/C. Two Hornet or Harrier squadrons per year are due to be re-equipped, requiring twenty F-35s a year to be delivered.

The first USMC F-35C unit, VMFA-314 the 'Black Knights', was certified 'safe for flight operations' in March 2020 at Marine Corps Air Station (MCAS) Miramar. The first operational F-35C squadron, the US Navy's VFA-147 the 'Argonauts', is expected to deploy with *Carl Vinson* (CVN-70) in 2021 whilst VMFA-314 is to deploy to another, as yet un-named carrier shortly afterwards. The digital combat system that is the F-35B/C Lightning II is at the dawn of its operational career but is already maturing into an outstanding embarked fighter. It will be fascinating to see how its use evolves with greater front-line exposure and continuing software upgrades over the next decade.

The planned acquisition numbers illustrate how the USMC's F-35B short take-off and vertical landing (STOVL) Lightning IIs will become an increasingly important component of the front-line naval air combat force over coming years. USMC Commandant, General David Berger, briefed the

press in February 2020 that the USMC must become more 'unpredictable' and he sees the 'Lightning Carrier' as a means of achieving this. The concept was evaluated in October 2019 when *America* (LHA-6) deployed with thirteen F-35Bs of VMFA-122, the 'Flying Leathernecks' and two MV-22Bs of VMM-166, the 'Sea Elk', embarked. The ship is one of two new 'aviation-centric' amphibious assault ships with no well deck, using the volume made available for improved aviation maintenance areas and greater aircraft fuel stowage. The second, *Tripoli* (LHA-7), was delivered on 28 February 2020. Berger said that the *America* deployment marked 'the birth of the most lethal, aviation-capable amphibious assault ship to date' and added 'you would like to see one of those big decks one time go out with two squadrons of F-35s and next time fully loaded with MV-22s and another with a 50-50 combination'. Given this enthusiasm, the plan to build ships after *Tripoli* with the well deck restored seems difficult to comprehend since they will have to operate close to a hostile shore near other amphibious ships to put forces ashore in landing craft. Their DMO capability would be limited and their ability to support F-35Bs reduced. The *America* deployment was apparently the largest number of F-35s yet operated at sea. However, the trial revealed that F-35B command, control, communications, computing and intelligence (C4I) capabilities were significantly more capable than those of the ship. To make the 'Lightning Carrier' concept an unqualified success, the latter will need to be upgraded.

Another sign of changing times occurred in April 2020 when the US Navy exercised a U$84.7m contract option with Boeing to procure three further MQ-25 Stingray unmanned aerial tankers to add to the four already on order. The T-1 prototype flew on 19 September 2019 and performed exceptionally well with no problems. The first engineering development model (EDM) airframes are expected to be ready at the end of 2021, by when T-1 will have collected a wealth of early flight data. EDM airframes will first undergo carrier suitability tests together with land-based catapult launches and arrested recoveries. These will be followed by carrier-based sea trials and tests of their in-flight refuelling capability before the target initial operational capability (IOC) is reached in 2024. BAE Systems has been awarded the contract to supply the type's vehicle management system and IFF equipment.

The amphibious assault ship *America* (LHA-6) pictured with no fewer than thirteen F-35B Lightning II strike fighters on her deck in October 2019. The potential of the 'Lightning Carrier' is exerting considerable influence on US Navy thinking. *(US Navy)*

The T-1 prototype MQ-25A Stingray unmanned aerial tanker flew for the first time on 19 September 2019, reportedly performing exceptionally well. Seven prototype versions have been ordered to date. *(Boeing)*

Bell-Boeing handed over the first CMV-22B carrier on-board delivery (COD) variant of the Osprey tiltrotor to the US Navy in February 2020. The new type is expected to make its first deployment in the course of 2021. *(Boeing)*

The latest French F3-R standard Rafale fighter variant reached initial operating capability early in 2020. This picture shows one of the upgraded aircraft in the course of trials on *Charles de Gaulle* in November 2019. *(Cyril Cosmao/Dassault Aviation)*

Bell-Boeing handed over the first CMV-22B Osprey carrier on-board delivery (COD) aircraft to the US Navy in February 2020. The aircraft was taken on charge by air test and evaluation squadron HX-21 at Naval Air Station (NAS) Patuxent River for testing. The first operational aircraft are scheduled to deploy to *Carl Vinson* in 2021. CMV-22Bs can carry 6,000lbs of freight and/or personnel over a range of 1,150 nautical miles and the navy is currently procuring thirty-nine to replace the aging C-2A Greyhound.[6] The first squadron to operate the new type, Fleet Logistics Multi-Mission Squadron 30 (VRM-30) the 'Titans', was formed at the end of 2018, initially using USMC Ospreys for training. Subsequently, in October 2019 Fleet Logistics Multi-Mission Wing 1 (COMVRMWING 1) was commissioned at NAS North Island to oversee the type's introduction.

Away from the US Navy, the French F3-R standard Rafale fighter has reached IOC. It features a Thales RBE2 active electronically scanned array (AESA) radar, a new electronic warfare system, integration of the Sagem air-to-surface weapon and an automatic ground collision avoidance system. By the end of 2020 F3-R Rafales are also expected to be able to use the Meteor air-to-air missile and the Thales Talios targeting pod. Development work on a further improved F4 version has been funded under a €2bn (US$2.2bn) contract awarded in January 2020.

AMPHIBIOUS WARFARE

In March 2020 General Berger released his Force Design 2030 Plan for the USMC.[7] Whilst decisions on redesigning traditional Marine Expeditionary Unit (MEU) structures and the adoption of a new Marine Littoral Regiment concept were deferred for further analysis and trial, capabilities such as heavy tanks, traditional artillery and bridging companies ranked high amongst those singled out for de-emphasising or deletion as the corps evolves as part of a distributed maritime strike force. Berger has also decided to reduce the number of F-35Bs per squadron from sixteen to ten, saying in April 2020 that he was not yet convinced that the Corps has a clear understanding of F-35 capacity requirements in the future force. To help with this, he is seeking an external assessment of the new plan relative to national defence strategy objectives and evolving naval and joint warfighting concepts. He stressed that the reduction is not due to any lack of confi-

dence in the aircraft but reflected a desire to make it 'manageable and embarkable in ships'. This could lead to further adjustment – 'we may over time learn that ten is the wrong number, it could be eleven, it could be twelve'. He added that the independent review is also likely to influence the total number of F-35s eventually procured for the USMC.

The Commandant General of the British Royal Marines (RM), Major General Matt Holmes, has also confirmed that the RM are to undergo significant changes that will see an expansion of the trend towards smaller units adopting a 'commando raid' style approach from the sea. The transformation is very similar to that envisaged for elements of the USMC and the embarkation of commando teams in ships of the *Queen Elizabeth* class with assault Merlin HC 4s operating alongside F-35Bs is likely to be a critical element of the way forward. By 2021 all twenty-five Merlin HC 4s will have been delivered for operation by 845 and 846 Naval Air Squadrons (NAS).

The Royal Australian Navy's amphibious assault ship *Adelaide* demonstrated the innate flexibility of this type of warship when she was deployed as part of Operation 'Bushfire' to assist to the country's response to wildfires that severely impacted parts of the country. She is seen here off the coast of Eden, New South Wales on 6 January 2020 with fires still raging out of control in the background. *(Royal Australian Navy)*

The last year has seen big-deck amphibious ships used in a variety of roles that underline their flexibility. In January 2020, the Royal Australian Navy's amphibious assault ship *Adelaide* was one of a number of vessels deployed in response to a major outbreak of bushfires, providing humanitarian and logistical support over a three week period from a position off the coast of New South Wales. Later, in March the French Navy announced that their LHD *Tonnerre* was being deployed to the island of Corsica to ease strain on the island's medical facilities by evacuating COVID-19 patients to mainland France. Sister-ships *Mistral* and *Dixmude* were subsequently deployed to the Indian Ocean and Caribbean as part of France's response to the pandemic.

New amphibious helicopter carriers continue to be built. Most significantly, the long-awaited first Chinese Type 075 amphibious assault ship was launched at the Hudong-Zhonghua Shipyard, Shanghai during September 2019. Displacing over 30,000 tons, the design is larger than a French *Mistral* and broadly comparable to the Italian *Trieste*. It can carry around 30 helicopters, landing craft in a well deck aft and over 1,000 naval infantry. In mid-April 2020 there were press reports that a fire had broken out in the well deck and images showed black smoke billowing from her across the shipyard. The fire was extinguished but the extent of damage and the delay it might cause to her programme is, as yet, unknown. A second Type 075 is fitting out in the same shipyard following launch on 22 April 2020.

The Italian amphibious assault ship *Trieste* was

Good progress is being made with construction of the Italian Navy's new amphibious assault ship *Trieste*, pictured here at Fincantieri's yard at Castellamare di Stabia near Naples on 10 October 2019. *(Conrad Waters)*

A prototype Sikorsky CH-53K King Stallion heavy lift cargo helicopter, latest iteration of the enduring Sea Stallion family. Problems with the development programme are now reportedly resolved and deliveries of production aircraft are expected to commence over the coming year. *(Lockheed Martin)*

launched in May 2019 at Castellammare di Stabia near Naples, subsequently sailing for final outfitting at Fincantieri's Riva Trigoso yard in La Spezia. She is to replace the veteran carrier *Giuseppe Garibaldi* and is designed to operate F-35Bs and both Italian Navy and Army helicopters. She has a ski-jump and accommodation for a complement of 460 plus 600 aviation and embarked military force personnel. Leonardo is providing a sophisticated combat system which is to include a SADOC 4 command management system, a Kronos Star Fire AESA radar, a Kronos Power Shield AESA long-range surveillance radar, conformal IFF and an integrated communications suite with a multiple data-link processor. The ship's twin island structure owes much to the British *Queen Elizabeth*, of which she resembles a cut-down variant.

The Commander-in-Chief of the Russian Navy, Admiral Nikolai Yevmenov, announced in January 2020 that plans are well advanced for two new 'universal' amphibious assault ships to be built for the Russian Navy. Their design is apparently evolved from the French *Mistral* class. Two of this type were under construction for Russian service before the contract was cancelled due the embargo placed on European arm sales to Russia, the ships being sold on to Egypt. Yevmenov said that the new ships will exceed *Mistral* 'in terms of seaworthiness, operational and construction characteristics'. Orders for the Ka-52K Katran attack helicopter intended to operate from the Russian *Mistral*s were cancelled in 2015 but it is possible that the type will be restored to production if the assault ship acquisition goes ahead.

PROGRESS WITH AMPHIBOUS WARFARE AIRCRAFT

The most important rotorcraft currently under development for USMC amphibious operations is the CH-53K King Stallion heavy lift cargo helicopter, latest iteration of the enduring Sea Stallion family. Late technical issues have delayed its planned IOC but Lieutenant General Steven Rudder told the HASC in March 2020 that problems with CH-53K development have now been resolved and Sikorsky has briefed that all but two Lot 1 helicopters will be built with the fixes in place. Moreover, those two would have them before delivery to the Marine Corps. Rudder was very positive about CH-53K progress saying that by the autumn of 2020 the first aircraft would be at MCAS New River, North Carolina, and there would be four in early 2021. Initial operational and test and evaluation (IOT&E) is to commence in May 2021 with the first operational deployment targeted for late 2023 or early 2024.

Less positively, the last year has seen significant changes to the planned Marine Air-Ground Task Force Unmanned Aerial System (MUX). A year ago

The Northrop Grumman MQ-8C Fire Scout has now achieved initial operational capability but is continuing to be developed as its primary role has switched to providing targeting and surveillance data for the Littoral Combat Ships on which it will be embarked. In early May 2020, Northrop Grumman commenced testing a Fire Scout equipped with the Leonardo Osprey 30 (AN/ZPY-8) active radar that will support this function. *(Northrop Grumman)*

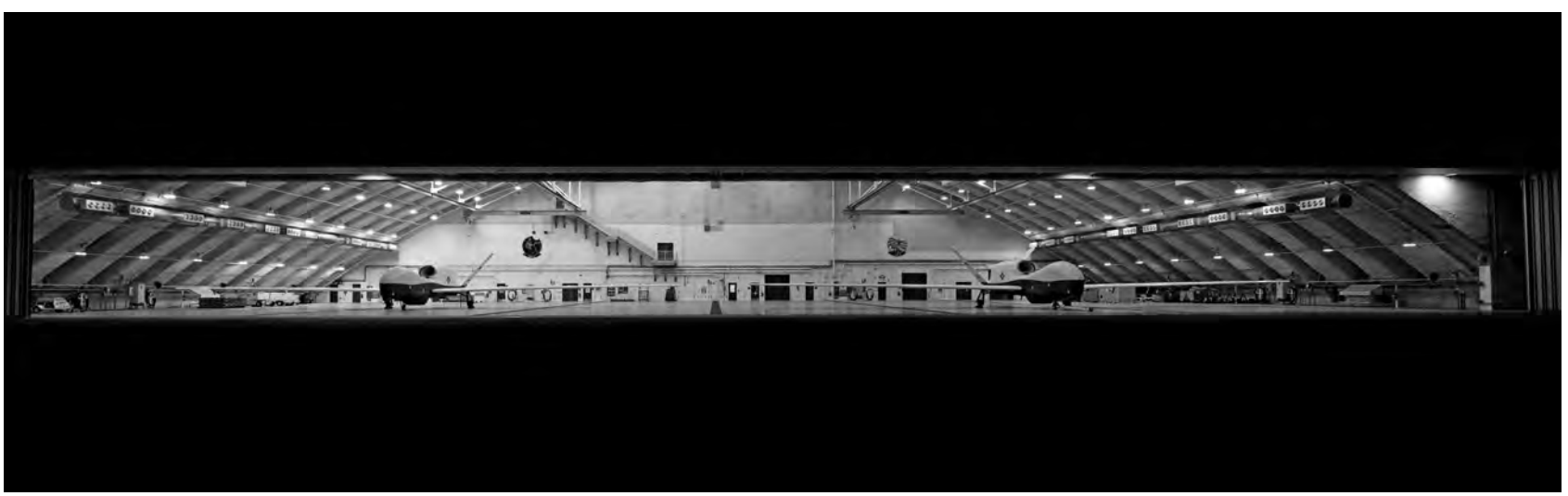
Marine Corps Headquarters described airborne early warning (AEW) as the primary capability of MUX, so as 'to allow greater lethality … whilst amphibious ships are operating separately from carrier strike groups'. In March 2020, however, General Rudder told press that the programme now looks very different, having evolved into a family of systems after it was appreciated that all the requirements in the original specification could not be fitted into a single air vehicle capable of vertical take-off and landing from a ship's helicopter deck. Rudder said that General Berger wants to see rapid progress and the quickest way to achieve this is with 'some sort of land-based, high-endurance' unmanned aerial vehicle (UAV) that can spend 24 hours over an amphibious force with 'all the networking, early warning and electronic warfare capabilities' necessary if there is no carrier strike group nearby. It would be complemented by a smaller and less capable but embarked UAV. At present the US Navy and USMC operate the small RQ-21 Blackjack UAV, launched from ships by a pressurised air catapult and recovered by a 'Skyhook' system, and the MQ-8 series rotary-wing UAVs. Rudder believes that the shipboard variant of the Marines' programme is probably RQ-21 Plus.[8]

The first British P-8A Poseidon was delivered to the Royal Air Force at the end of October 2019. All nine that are currently planned will have arrived in the United Kingdom before the end of 2021. *(Crown Copyright 2019)*

PROGRESS WITH SEA CONTROL AND SURVEILLANCE AIRCRAFT

Meanwhile, the US Navy has been making progress with its own UAV capabilities, declaring IOC for the Northrop Grumman MQ-8C Fire Scout at the end of June 2019. It is eventually intended that thirty-eight MQ-8Cs will follow thirty earlier MQ-8Bs into service. Based on the Bell 407 airframe, the MQ-8C variant had originally been intended to defeat swarm attacks by small craft on Littoral Combat Ships (LCS). However, the US Navy has now changed its primary mission to provide the LCS with an over-the-horizon targeting capability. The type has an endurance of up to twelve hours and is to be fitted with radar and made Link 16 capable. The change of priority followed a shift of focus towards operations in the Pacific but another factor was the realisation, after a demonstration by the smaller MQ-8B, that the LCS lacks the magazine space to embark sufficient air weapons for the aircraft to carry out the original primary role. Given the amount of effort that went into development, the mismatch with ship design is hard to comprehend.

The British Royal Navy continues to experiment



The first pair of operationally-deployed US Navy MQ-4C Triton unmanned patrol aircraft pictured in a hangar at Andersen Air Force Base, Guam on 26 January 2020. The aircraft are deployed to Guam as part of an early operational capability (EOC) test to further develop the concept of operations relating to this new system. *(US Navy)*

with various miniature UAVs. Based at Royal Navy Air Station (RNAS) Culdrose, 700X NAS is currently the navy's UAV test and evaluation unit. In early 2020 it deployed RQ-20B Puma UAV systems to northern Norway in the amphibious transport dock *Albion* to operate alongside 47 and 45 Royal Marine Commandos in harsh winter conditions. The AeroVironment RQ-20 Puma is a small, hand-launched, electrically-powered UAV with over two hours endurance fitted with an electro-optical camera. It was launched from a small landing craft and data was fed to *Albion* using artificial intelligence.

At the other end of the size scale, the first British P-8A Poseidon was delivered to the Royal Air Force (RAF) during October 2019. The type is to be operated by the RAF's 120 and 201 Squadrons at RAF Lossiemouth using aircraft from a common pool. The second P-8A was delivered in March 2020 with three more due before the end of the year and the last of nine on order in November 2021. Initial operating capability was declared on 1 April 2020. The type is designated Poseidon MRA 1 in RAF service but is identical to the aircraft operated by the US Navy and Royal Australian Air Force (RAAF). No further orders of Poseidons are currently planned for the US Navy beyond the 117 already purchased but India intends to acquire six more to add to the twelve already delivered or contracted. New Zealand, Norway and South Korea also have outstanding orders for the type for delivery from 2022 onwards.

The US Navy finally deployed the first two MQ-4C Triton UAVs to Guam in January 2020 for operation by a detachment from Unmanned Patrol Squadron 19 (VUP-19) the 'Big Red' following delays caused by a crash-landing of one of the aircraft in California in September 2018. It expects to achieve IOC for the type in 2021. VUP-19 operates under the Commander Task Force 72 together with other reconnaissance and surveillance assets in the Pacific.

NAVAL AVIATION TRAINING

This overview commences by examining US Navy aircrew training – the largest organisation of its kind in any navy – and compares it with that conducted by the British Royal Navy. The Royal Navy's Air Engineering Branch is also described as an example of how evolving technology is changing this particular training requirement. The overview concludes with a brief look at the use of aircraft for the operational training of a broad spectrum of naval forces, for example in the air defence role.

Three US Navy T-6B Texan II aircraft assigned to the navy's Training Air Wing Five fly over Naval Air Station Whiting Field, Florida in June 2016. The Texan II provides trainee US Navy and USMC pilots with their primary instruction. *(US Navy)*

US Navy Air Training: Aircrew training for the US Navy and USMC is shared, with instructors drawn from both services. However, in line with US Navy policy, the maintenance of aircraft based permanently ashore is carried out by civilian contractors. Over 1,000 students a year pass through the system and flying training takes place in phases, starting with primary instruction in the Beechcraft T-6A/B Texan II. Designed to meet a joint US Navy/US Air Force training requirement, it has also been widely exported. It has an all-digital, open-architecture glass cockpit with three 5in by 7in (12.7cm by 17.8cm) colour multifunction displays and a head-up display. Tactical situation displays or a moving map can be selected, allowing pilots to be taught to use the aircraft rather than just fly it from the beginning of their training. Five squadrons of T-6Bs are divided between NAS Whiting Field, Florida, and NAS Corpus Christi, Texas. A 6th squadron operates T-6As at NAS Pensacola, Florida, to train naval flight officers. The T-6B is powered by a single Canadian Pratt & Whitney PT6A-68 turboprop engine driving a four-bladed propeller, which gives it the handling quality and 'feel' of a fast jet. In 2020 the USN had around 50 T-6As and 250 T-6Bs.

On completion of the T-6B course, pilots are split into three streams. Those moving on to fast jets go to one of four Boeing T-45C Goshawk squadrons split between NAS Meridian, Mississippi, and NAS Kingsville, Texas. A fifth squadron at Pensacola trains naval flight officers. The T-45C also has a digital 'glass' cockpit and is being further upgraded with a virtual mission training system (VMTS), which allows students to carry out realistic tactical radar training using inputs from the instructor. Derived from BAE Systems' Hawk trainer, the T-45's structure was strengthened for deck landing and all US Navy fast-jet pilots carry out their initial carrier qualification (CQ) on this type. After completing the T-45C course, both pilots and naval flight officers move on to Fleet Replacement Squadrons (FRS) where they are taught to fly the operational types that make up the fast-jet elements of carrier air groups. Simulator

training forms a growing part of every training syllabus. They have been used for many years to give pilots cockpit familiarity and emergency procedures but now digital systems allow their use in a significant number of training sorties for some types. Roughly 200 T-45Cs remained in USN service in 2020 and all are being given a service life extension programme (SLEP) to increase individual airframe life.

Pilots selected for fixed-wing aircraft other than fast jets move from the T-6B onto the Beechcraft T-44C Pegasus, a derivative of the King Air 100 powered by two Canadian Pratt & Whitney PT6A-34B turboprop engines driving three-bladed propellers. They are not stressed for deck landing but the operational types students will move onto, such as the E-2D Hawkeye, have two pilots and this allows CQ to be carried out as part of operational flying training. T-44Cs are operated by two squadrons based at Corpus Christi. The type has been in service since 1977 but the fifty or so aircraft that remained in 2020 have been upgraded with LCD 'glass' flight displays and other systems representative of the front-line types that students will move onto. Procurement of a replacement for the T-44C Beechcraft is due to commence from FY2023.

Pilots selected for helicopter training currently move from the T-6B onto the Bell TH-57B/C Sea Ranger, which is based on the Model 206B-3 JetRanger. These are operated by three squadrons at Whiting Field, all of which are tasked with primary and advanced rotary-wing training and intermediate training for tilt-rotor pilots. The type has been in service since 1968 with around forty TH-57Bs and seventy TH-57Cs remaining in service as of 2020. The US Navy stated a requirement for a new advanced helicopter training system, designated TH-XX, in 2016 and in January 2020 it was announced that Leonardo had won the contract with a system based around its TH119 design, an AW119 Koala variant which is to be designated the TH-73A in US Navy service. The initial contract calls for 32 aircraft out of a planned total of up to 130 helicopters to be delivered between late 2020 and 2024, all built in Philadelphia, Pennsylvania, with a customer support centre at Whiting Field and simulator facilities.

Qualified aircrew from the various streams move on to be trained on operational types in the FRS, where they learn to fly aircraft safely, gain appropriate qualifications and operate them by day or night in any weather. Next they are taught to use aircraft as a weapons system with simulators for part of the syllabus to allow familiarity with weapons which cannot be fired or dropped routinely. Digital technology allows simulators to be linked so that pilots can fly in formation, use section tactics to engage enemies in varying numbers, make use of shared data and encounter realistic combat situations that can be played out using data from ships, UAVs and satellites. The threat libraries available to aircrew in aircraft such as the F-35B/C and the type's sensor fusion are so extensive that training sorties involving, for example, F-35Cs, EA-18G Growlers and E-2D Hawkeyes working together with a battle group can actually be performed more realistically in simulators than by flying the real aircraft within range or exercise environments that are limited in scope. It is also possible for complete operational sorties to be practiced in simulators before being flown in the real aircraft. Data transfer is becoming so important that range facilities big enough to allow realistic operational scenarios to be played out only exist in a limited number of places.

The T-45C Goshawk – a variant of the BAE Systems Hawk – is used to train US Navy fast jet pilots up to and including their initial carrier qualifications. This photograph shows a T-45C of Training Squadron 9 (VT-9) in US Marine Corps markings being prepared for launch from the carrier *George H. W. Bush* (CVN-77) in August 2018. *(US Navy)*

Training does not cease after aircrew join front-line squadrons. They undergo regular checks to maintain qualifications and standards and new software upgrades for their aircraft have to be absorbed ashore after their application. Air wings have to work up to attain fleet standards before they can embark and the whole carrier battle group has to pass an operational readiness inspection (ORI) before deployment. Post-graduate training for selected aircrew such as the 'Top Gun' School at NAS Fallon, Nevada produces instructors of the highest calibre who pass on their skills to other front-line aviators. The US Navy carrier fleet is sufficiently large for operational carriers to be tasked in rotation as CQ decks for pilots in the training pipeline and FRS squadrons. Moreover, the joint forces base at Lakehurst, New Jersey, has both steam and EMALS catapults and arrester gear that could be used for training if necessary in addition to their primary developmental use.

Royal Navy Air Training: Royal Navy flying training is broadly similar in concept to that in the United States but, unlike the US Navy, the Royal Navy only has full control of its own operational training. All other training for aircrew across the British Armed Forces is provided by the UK Military Flying Training System (MFTS), a public-private partnership comprising the MFTS Project Team, the Directorate of Flying Training within 22 (Training) Group RAF and the Ascent joint venture between Babcock and Lockheed Martin.[9] Some of its aircraft, such as the Hawk T2, are MOD-owned, others are owned or leased by Ascent and are civil-owned but military registered so that they can carry out the full range of designated tasks including, where necessary, combat manoeuvring and low flying. Simulators and digital teaching aids are included in the Ascent contract which is due to run until 2033 and instructors are a mix of RAF, Royal Navy, British Army and civilian qualified flying instructors (QFIs).

Potential Royal Navy and Royal Marines aircrew are first graded for flying aptitude in Grob Tutor T1 aircraft of 727 NAS at RNAS Yeovilton. Those selected as being suitable for pilot and observer training are appointed to 703 NAS at RAF Barkston Heath for elementary training in Grob Prefect T1 aircraft, twenty-three of which were procured by Ascent in 2017. The Prefect has a Rolls-Royce M250-B17F turboprop engine developing 380 shp, digital avionics with information displayed on 'glass' screens and a retractable undercarriage. About sixty Royal Navy and Royal Marines pilots a year pass through 703 NAS and about thirty observers for their Phase 1 and 2 training. The squadron has a Royal Navy commanding officer and some naval QFIs; the bulk of its instructors could be British Army, RAF or civilian.

Pilots selected for fast-jet training move to 4 Flying Training School (FTS) at RAF Valley, where they join RAF students in 72 (Reserve) Squadron RAF equipped with Beechcraft Texan T1 aircraft. These are essentially identical to the T-6Bs used by the US Navy. It has a digital 'glass' cockpit, handles like a fast jet and the mission system is capable of generating virtual air-to-air targets for the student pilot to intercept and engage. It can also simulate the release of air-to-ground ordnance and score the effectiveness of the release. Ten Texan T1s were in use as of 2020.

Royal Navy and Royal Marines fast-jet students stay within 4 FTS at Valley and move from the Texan to the BAE Systems Hawk T2 operated by 4 (Reserve) and 25 (Fighter) Squadrons RAF. This is similar to the US Navy T-45C, although it is not strengthened for deck landing. It is powered by a single Rolls-Royce Adour 951 turbofan delivering 6,500lb of thrust and which has full authority digital engine control. The 'glass' cockpit has three multi-function displays which show navigation, weapons and system information with computer access via an up-front control panel and touch-screen technology. Radar and threat warning inputs are generated by the instructor. RN and RM pilots who pass out of 4 FTS successfully move on to F-35B training at RAF Marham.

Pilots who are selected for rotary-wing training move from Barkston Heath to 1 FTS at RAF Shawbury where they join 705 NAS which operates the Airbus Juno HT1. The MFTS operates a total of twenty-nine Junos, which are used by 705 NAS together with Army Air Corps and RAF squadrons. The Juno HT1 has two Turbomeca Arrius 2B turboshafts, each developing 708 shp. The type entered service in 2018. They have a digital 'glass' cockpit and a defensive aids simulator operated by the instructor, in this case a qualified helicopter instructor or QHI. All Junos are wired for an L-3 Wescam electro/optical camera installation although only about ten are fitted at any one time. Simulators are used to teach part of the syllabus and to achieve easy familiarity with digital systems that will reduce the gap between training and the front-line helicopters they will move onto. 202 Squadron at RAF Valley forms part of I FTS and is equipped with three Airbus Jupiter HT1 helicopters which are used to provide over-water and mountain flying instruction.

Observers carry out their Phase 1 and 2 training in 703 NAS at Barkston Heath in Prefects before moving to 750 NAS at RNAS Culdrose for Phase 3 training on the Beechcraft Avenger T1. Like the US Navy T-44, the Avenger is a derivative of the King Air powered by two Canadian Pratt & Whitney PT6A-60A turboprops, each delivering 1,050 shp. 750 NAS is part of the MFTS and its four Avengers provide airborne surface search, ground-mapping radar and lead-in tactical training for Royal Navy observers destined to fly in Merlin anti-submarine and airborne surveillance squadrons, as well as the Wildcat. It also trains RAF system operators destined for Sentry AWACS aircraft and, eventually, the Wedgetail.

Trainee Royal Navy and Royal Marines aircrew are first appointed to 703 NAS at RAF Barkston Heath for elementary training in Prefect T1 (Grob 120TP) aircraft operated as part of the UK Military Flying Training System (UKMFTS). *(Crown Copyright 2018)*

Royal Navy Air Engineering Training: The technical training needed to train officers and men to maintain naval aircraft has changed significantly over the past decade as stealth and digital technologies evolve. In the Royal Navy, air engineering officers undergo university training that is initially similar to their mechanical, weapons and nuclear colleagues, with specialised post-graduate training subsequently provided in air disciplines. Air engineering training for both officers and ratings forms an element of the Defence School of Marine Engineering, HMS *Sultan*, at Gosport, Hampshire. The school has a training support organisation which is the enabling focus for academic instruction in every discipline. Initial air technician training is the responsibility of 764 NAS.

The air engineering training department – officially the Royal Naval Air Engineering and Survival School – is made up of six specialised wings, each given the ships' name of a former RN air station or Fleet Air Arm establishment. They are:

- **Goldcrest Wing:** Mathematics and computer system technology.
- **Falcon Wing:** Communications and radar technology.
- **Ariel Wing:** Air weapons and electrical technology and the use of technical publications.
- **Seafield Wing:** Survival equipment technology.
- **Condor Wing:** Mechanical systems.
- **Fulmar Wing:** Training standards, administration and design.

Sultan occupies the site of former RNAS Gosport and uses hangars as workshops and large training areas. In one of these, all trade technicians are instructed in workshop practices including tool control procedures, aircraft sheet metal work (including battle damage repair) and aircraft practical wiring work. Ratings in the avionics trade group are taught basic sheet metal work, practical aircraft wiring together with printed circuit board modification and repair techniques. Air engineering officers are given acquaintance courses in every discipline. In another hangar, helicopter airframes are used by the aircraft maintenance group to give Phase 2 training. This covers practical aircraft maintenance and trade training on recently retired aircraft types such as the Sea King and Lynx. A newer hangar was purpose-built for use by 760 NAS, the engineering training squadron, which provides lead-in training

The Royal Navy School of Aircraft Handling (SAH) at RNAS Culdrose uses retired Sea Harrier jets on a concrete dummy deck laid out like that on an aircraft carrier to help trainee handlers learn the basics of safe flight-deck operations. Whilst not being certified to fly, the Sea Harriers can taxi and simulate take-offs and landings. *(Crown Copyright 2016)*

in the supervision and administration of aircraft maintenance and line procedures using real aircraft and training aids. The squadron also runs courses in management, administration and operational training subjects such as aircraft husbandry, nuclear/chemical/biological warfare and aircraft decontamination. From 2017 an accelerated apprentice scheme has been operated from which students graduate as Leading Air Engineering Technicians.

As navies work more closely together, engineering standards have to be compatible. For example, when the initial Royal Navy and RAF F-35B pilots and technicians were embedded in Marine Fighter Attack Training Squadron 501 (VMFAT-501) at MCAS Beaufort for training, all qualifications were equivalent to those gained by their American counterparts. The value of this will be evident when USMC F-35Bs embark in *Queen Elizabeth* in 2021, helping engineering standards and practises integrate seamlessly with those of the ship and the other aircraft embarked.

In the past, air engineering instruction relied almost exclusively on old airframes and systems salvaged from them. However, contemporary aircraft with their digital systems require more advanced training aids. Those used by the F-35 give a good illustration. Air engineering personnel are instructed using purpose-built, hands-on training mock-ups backed by virtual training for core tasks described by Lockheed Martin as 'a more immersive training experience'. A family of training devices, effectively parts of the airframe specially constructed to allow the wear and tear of constant maintenance, are used to give applied instruction in tasks such as the loading of weapons, replacement of major components, and undercarriage and ejection seat maintenance. The focal point of F-35 maintenance is the aircraft systems maintenance trainer (ASMT), which is a virtual environment used in a classroom setting. Technicians are able to carry out every aircraft maintenance task using the data in their portable maintenance aid (PMA), essentially a laptop computer. The virtual environment teaches diagnostic principles, performance of set tasks, the location of line-replaceable components, the proper use of ALIS, and the full use of the PMA itself. Instructors have a dedicated interface which allows them to support up to twelve

students at any one time, assign tasks and monitor individual progress. ASMT automatically grades their results and can also be used at ship or squadron level for refresher training.

As previously mentioned, the three-dimensional training aids are effectively parts of the real aircraft specially constructed for the instructional role. Examples include the weapons loading trainer (WLT), which has a fully functional representation of F-35 weapons bays, maintenance interface panel and the external weapon hardpoints under the wings. A range of realistic but inert weapons are provided to be loaded exactly as they would be on the real aircraft. The integrated power package maintenance trainer (IPPMT) allows training on power package pre and post-flight procedures, including its removal and replacement using the appropriate support equipment. The landing gear maintenance trainer (LGMT), as its name implies, is a partial airframe that allows hands-on installation or removal of the main landing gear or any of its components. The ejection seat maintenance trainer (ESMT) is an accurate representation of the cockpit area that can be used for instruction in maintenance, removal and replacement of the seat. As an added bonus it can be used to teach pilots and engineers how to get into and out of the cockpit safely and to teach the latter how to carry out engine runs. The engine lift fan removal and installation trainer (ELFRIT) is specific to the STOVL F-35B and is an accurate representation of the fuselage section from which components can be removed and replaced. It is worth noting that the Merlin and Wildcat helicopters also have training systems incorporating purpose-built instructional aids, the former at RNAS Culdrose and the latter at RNAS Yeovilton.

Beyond training in air engineering, instruction in safe aircraft handling is another skill that needs to be taught. The Royal Navy School of Aircraft Handling (SAH) at RNAS Culdrose uses dummy F-35Bs to practise flight deck movements with aircraft tractors. They match the real aircraft's dimensions and tanks within the airframe can be filled with water to simulate empty and fully-loaded aircraft. They operate on a concrete dummy deck laid out like that on an aircraft carrier. In addition to the dummy F-35Bs, the SAH also uses Sea Harriers that are maintained to a standard that allows them to taxi and simulate take-offs and landings (although these are reaching the end of their engine lives and replacements are being sought). Culdrose-based helicopters are used for training in rotary-wing activity. Aircraft dummies on pans away from the dummy deck are set on fire to give realistic firefighting training for handlers who provide carriers with the specialised teams that must respond instantly to a crash on deck.

Another important training function required to support effective maritime aviation is the School of Meteorology, also at Culdrose. It trains officers and ratings to provide weather forecasting detachments in aircraft carriers and at air stations. The Royal Navy's air traffic control officers and ratings are trained by the RAF at the Central Air Traffic Control School at RAF Shawbury.

One problem that the Royal Navy has to resolve in its new carriers is that – while digital maintenance and support systems for specific aircraft might share commonality with those of other international users of the type – these systems lack interoperability across other aircraft types in an embarked TAG. ALIS is shared with the US armed forces and other F-35 users; the Merlin has its own unique system and so does the Wildcat. However, the carrier has to operate seamlessly with all three. Apache and Chinook helicopters, when they are embarked, add further levels of diversity. Moreover, units that are provided by the Army Air Corps and the RAF are manned by soldiers and airmen who may never have been to sea before and do not have the sea sense that sailors gain in their training and time spent at sea. In effect, what was until recently a cohesive, ship-centric Fleet Air Arm under a single flag officer has been replaced with a disparate group of administrative commands, each often using different maintenance, administrative and logistic tools to sustain its aircraft. The skills, underpinned by meticulous training at every level, needed to produce an effective carrier strike force are complicated and very demanding to acquire, easy to lose and extremely difficult to regain. Hopefully, the disparate elements that make up future TAGs will find the leadership and dedication to overcome these drawbacks.

A Royal Navy Hawk T1 from RNAS Culdrose in 736 NAS markings. *(Lee Howard)*

Operational Training Using Aircraft: The need for continuous training to maintain operational efficiency affects modern fleets in many ways. The Royal Navy is a good example. Its Flag Officer Sea Training (FOST) organisation, based in Plymouth, is responsible for every aspect of this important work. The quality of training provided by FOST is so high that a number of foreign navies also use the organisation to work up their ships. FOST needs considerable air input to the training scenarios that are provided on a weekly basis and these are drawn both from front-

line naval air squadrons and from 'aggressor' units simulating hostile equipment and tactics.

736 NAS, equipped with Hawk T1s, is one of these units. It was due to be replaced in late 2020 by a Ministry of Defence-contracted organisation to have been known as Air Support for Defence Operational Training (ASDOT). This was to have provided its own aircraft and personnel for air threat simulation for all three services but the project was cancelled in the course of 2019. The Ministry of Defence has been reluctant to say what will replace 736 NAS but it currently seems that it will continue in its current role until at least 30 November and work is underway between the Royal Navy and RAF to determine its future after that.[10] The squadron also acts as a focal point for Royal Navy fixed-wing activity and a 'pool' for fast jet pilots that are not flying the F-35B.

Aggressor and other operational training is also supported by a number of private companies. Cobham Aviation Services is particularly prominent, operating around a dozen Dassault Falcon 20 aircraft under Ministry of Defence contracts. Another significant British company in the training and trials support market is Hawker Hunter Aviation, with a fleet largely comprised of refurbished former Swiss Air Force Hawker Hunters. They are particularly attractive for equipment trials because, as non-digital 'clockwork' aircraft, the problem of installing modern electronic systems quickly is greatly eased. Other Hunters have flown over 30,000 hours in the last decade under the control of private US-based operators on contract to the US Navy and the type has also supported operational training for France's *Marine Nationale* and other militaries worldwide.

The US Navy has similar requirements to the Royal Navy and operates squadrons of dedicated aggressor aircraft using former Swiss Air Force F-5N/F Tiger II fighters. These are divided between NAS Fallon in Nevada and NAS Key West in Florida. The Naval Fighter Weapons School, the Naval Air Warfare Development Centre and the Naval Air Strike Warfare Centre, all at NAS Fallon, operate a small fleet of F-16A/B variants as aggressors. The USMC has its own aggressor unit, VMFT-401, which flies F-5N/Fs from MCAS Yuma, Arizona. All these aircraft fly simulated profiles and tactics that could be used by potential adversaries and provide dissimilar air combat training for front-line strike fighter squadrons.

A number of private companies operate aircraft in support of Royal Navy and other British Armed Forces training requirements. This is a Dassault Falcon 20 jet owned by Cobham Aviation Services. *(Michael Leek)*

Notes

1. Ongoing developments relating to the *Theodore Roosevelt* saga have been regularly reported on the *USNI News* website – news.usni.org – in a series of articles by Megan Eckstein, Sam LaGrone and Ben Werner. Although other US Navy carrier crew members have been infected during the COVID-19 pandemic, *Roosevelt* is the only deployed carrier to have been impacted.

2. A detailed report on the French Navy's COVID-19 outbreak was provided in an article 'Florence Parly s'exprime devant les députés de la commission de la Défense nationale et des forces armée' posted to France's official defence website – www.defense.gouv.fr – on 17 April 2020. Thirty-six cases were initially reported to the French defence minister on 7 April, when a decision was taken to end *Charles de Gaulle*'s deployment. In addition to cases on the carrier, there were a further thirty-five infections on other ships in the carrier group.

3. See Ronald O'Rourke, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress – RL32665* (Washington DC: Congressional Research Service, 2020).

4. See David B. Larter's 'Defense Department study calls for cutting 2 of the US Navy's aircraft carriers' posted to the *Defense News* website – www.defensenews.com – on 20 April 2020.

5. See Malcolm Davis, 'Should Australia follow Japan and take the F-35 to sea?' posted to the Australian Strategic Policy Institute's *The Strategist* website – www.aspi strategist.org.au – on 23 January 2019.

6. The program of record for the CMV-22B Osprey variant is for forty-eight aircraft but it is far from clear that any more than the thirty-nine currently contracted will be ordered.

7. See David H. Berger, *Force Design 2030* (Washington DC: USMC, 2020).

8. More detailed reportage of the USMC's revised thinking on MUX was provided by Megan Eckstein's 'Marines Ditch MUX Ship-Based Drone to Pursue Large Land-Based UAS, Smaller Shipboard Vehicle' posted to the *USNI News* website on 10 March 2020.

9. The Ascent joint venture maintains a useful website at: ascentflighttraining.com.

10. The author is grateful to Emma Relton, the PR Officer at RNAS Culdrose, for providing this information.

4.2 TECHNOLOGICAL REVIEW

SEABORNE STEALTH

Some Considerations

Author:
Norman Friedman

Look around the ships built for the world's navies from the 1990s onwards, and you see shapes associated with stealth; with reducing radar cross section. This concept was first publicised in the air world with the F-117 Nighthawk attack aircraft, which made its first flight in 1981. Its faceted shape was intended to reflect radar pulses away from the radar painting it, to the point where its radar image – expressed as its radar cross section – nearly disappeared. The F-117 also exploited radar-absorbing material (RAM) and radar-absorbing paint. These features are now commonplace in the air world, to the point that there is a colour of grey US military paint said to be associated with radar absorption.

COUNTERING RADAR

It is worth asking exactly what stealth is supposed to do. Is it to render a ship altogether invisible? Is it to counter targeting? Is it to prevent anti-ship weapons from hitting? Typically radar range and definition depend on frequency (wavelength) for any given size of antenna. Missiles need sufficient definition or gain to lock onto their targets but they are small, so their seekers need to operate at short wavelengths. Longer ranges demand longer wavelengths and larger antennas. During the Cold War, for example, the Royal Navy distinguished (i) longer-range anti-targeting countermeasures from (ii) shorter-range defensive ones intended to confuse or defeat missiles which had locked onto – or were trying to lock onto – ships. Some ships carried powerful anti-targeting jammers. It is apparently more difficult to provide anti-radar cover at longer than at shorter wavelengths, but successful stealth at targeting frequencies might make it unlikely that a ship would be attacked at all. For reasons developed here, it seems unlikely that is possible. It is not just a matter of the physics of the radar and anti-radar covering and shapes, but also the fact that targeting may well be a cooperative operation among multiple radars, using off-board clues such as a ship's wake. Missiles trying to lock onto a ship are, however, more likely to operate singly.[1]

SEA SHADOW

Probably the first stealthy warship was the *Sea Shadow* catamaran built by Lockheed – which had also been responsible for the F-117 – as a 'black' (secret) project in the early 1980s. Its sides above its two hulls were canted inwards to meet at the top in a very narrow deck. The catamaran hull was very stable, so that the ship tended not to roll and, hence,

The Lockheed F-117 Nighthawk attack aircraft is commonly regarded as being the first operational aircraft designed around radar cross section reducing stealth technology. The concept has subsequently been widely emulated in warship design. *(US Air Force)*

An early example of a low radar profile warship design was the US Navy's experimental stealth ship *Sea Shadow* (IX-529), which was built by Lockheed in collaboration with the Navy and the Defense Advanced Research Projects Agency. Initially subject to high levels of secrecy, the project was never intended to be mission-capable, being used to explore a range of new technologies for surface ships. *(Lockheed Martin)*

The US Navy's *Zumwalt* (DDG-1000) class destroyer is an extreme stealth design intended to reduce radar cross section to a point below the prevailing radar noise created by the surrounding sea. The ship's sides are canted back from the horizontal to remove the radar-reflecting corner where the ship meets the sea, with the wave-piercing hull form adopted to avoid reflections being created by pitching. These features are shown to good effect in this image of the third and final class member *Lyndon B. Johnson* (DDG-1002), taken whilst the ship was being floated out from dry dock at her Bath Iron Works building yard on 9 December 2018. *(General Dynamics Bath Iron Works)*

not to change the angle its sides presented. The test craft was apparently quite successful as a demonstration that radar cross section could be drastically reduced. However, it had no operational virtues, and it did not last. Nothing similar was ever built.

However, the idea that even something the size of a frigate or destroyer could be stealthy was attractive. At the least, radar cross section could be reduced below that of the decoys which the ship could fire. That would be particularly useful if the decoys could simulate ship motion, even if only briefly, as in the Australian Nulka. The step beyond would be a drastic modification to reduce radar cross section to a point below the prevailing radar noise created by the sea around the ship.

USS *ZUMWALT*

This more extreme approach is typified by the US Navy's *Zumwalt* (DDG-1000) class. The most significant source of radar cross section is corner reflectors, because they reinforce the reflection of radar beams. For a ship, the biggest corner is the one created by a vertical side against the flat reflecting sea. If the ship's side is canted towards or away from the radar, the corner is removed, and reflection is considerably reduced. Once that is done, other sources of reflection can be addressed. Gun housings can be faceted to reflect radar away from them. The usual mass of deck equipment can be enclosed or, at least, hidden behind bulwarks which will reflect radar signals away from their source. Even scuttles can be a problem, because they admit radar beams as well as light, and the spaces behind the scuttles generally have corners which can produce radar highlights.

In the case of *Zumwalt*, the approach was to cant the sides back from the horizontal. The ship seems to have had a minimum radar cross section at only one draft, so she was provided with submarine-type ballast tanks to compensate for the reduction in weight as she burned fuel. She is roll-stabilised. Pitch is also an issue, because it changes the angle elements of the superstructure make with the sea. To eliminate pitching, the ship has a wave-piercing hull form. She does not ride up on waves like a conventional ship.

The only deck projections are the ship's deckhouses, which are angled and canted, the housings of her 155mm guns (the guns themselves are housed when not firing) and housings for the secondary battery. The designers also had to deal with the usual plethora of antennas, which might have created a problem because the dishes involved are potential radar reflectors. The solution, which turned out not to be entirely practicable, was to eliminate most conventional antennas in favour of flat electronically-scanned ones, which would not focus radiation back at an observing radar. That was practicable for radars but not, apparently, for the broader-band satellite antennas.

This extreme approach to stealth came at a considerable price. Quite aside from the ballast

tanks, keeping the ship's decks empty created something like a surfaced submarine, in which internal volume became a critical factor. Stealth is why *Zumwalt* is so large, and so expensive. There were limits even in her case. Her sides are at a shallower angle than apparently initially wanted; reportedly tank tests showed that the original design was likely to capsize in a rough-enough sea.

Zumwalt seems to have been born out of the widespread fascination with stealth, particularly after the F-117 performed effectively during the 1991 Gulf War.[2] *Zumwalt* was conceived as a land-attack destroyer, the idea being that this would be the primary post-Cold War naval mission. A key document argued that – in a particular scenario – a carrier battle group could not destroy enough targets, so a surface combatant armed with numerous Tomahawk missiles could make a considerable difference – if it could survive without the air-defence umbrella usually enjoyed by a carrier. *Zumwalt* is thus the surviving echo of the arsenal ship idea. Her stealth was wanted because much of her firepower resided in the guided shells of her 155mm guns. The land-attack concept is also reflected in the presence of a hangar at the stern for raiding craft.[3]

The price of anti-radar stealth was enormous; the US Navy abandoned plans to build around thirty *Zumwalt* class destroyers to replace the *Spruance* class.[4] The programme was cut to three ships, and there were attempts to reduce it further. It is not clear to what extent that can be traced to a feeling that the value of extreme shipboard stealth had been overstated. Although several navies seemed to be close to building similar surface combatants, their plans have evaporated in favour of more conventional designs.

PHYSICAL CHALLENGES

Physics suggests a major problem. To move through the sea, a ship has to push aside water, creating a wake. There is a reason it takes many tens of thousands of horsepower to propel a warship at 20 or 30 knots. The wake is visible to the eye, and also to radar. It may seem to be enough to reduce radar cross section to the level of noise, but an airborne radar system might well be able to correlate some potential targets with their actual wakes, rejecting most. At one time, it might have been difficult to examine numerous candidate targets detected by a radar looking into the noise. With the advent of cheap UAVs, however, it may be far more affordable and practical, at least anywhere near a coast.

A look at how the only major kind of true stealth warship, a submarine, is typically detected suggests that even the degree of stealth associated with *Zumwalt* may not be enough. Submarines have long produced sound signatures below the background noise level. Consequently, their enemies look for systematic signatures, since nature is random but man-made objects are not. The extraordinary lengths to which submarine designers have had to go to counter this detection strategy testify to just how effective it can be.

The submarine example suggests that the key factor in countering stealth is probably signal processing: there is a competition between reduced cross section and increasing processor power. Moore's Law posits that computer power doubles every 18 months, or even faster. Perhaps the greatest question is when this breakneck growth will stop. Every technology has followed an S-shaped growth curve, the near-vertical part of the 'S' looking like the exponential Moore's Law. Growth stops either for technological or financial reasons. Right now the hope for continued growth is quantum computing; which happens to be an ability to pursue multiple possible solutions to a problem in parallel. That seems to be exactly the way that multiple sub-noise level radar contacts could be evaluated, suggesting that ultra-stealth may not be worth its price.

This is aside from claims that objects which are stealthy at some radar wavelengths are easily visible at others. For years, for example, Russian radar developers have claimed that their metric-wave radars can detect stealthy aircraft and missiles. Sceptics point out that they are unlikely to have had access to stealthy US aircraft for tests.[5] It is, moreover, generally difficult, at least in aircraft, to reduce radar cross section in all directions. That makes multi-radar systems with netted outputs effective against stealthy aircraft. At least in theory, each radar sees the aircraft for only a short time, insufficient to create a viable track. The netted system puts together such detections into a meaningful track.[6] The US Navy's cooperative engagement capability (CEC) system is often described as anti-stealth for just this reason.

Probably the most difficult aspect of the *Zumwalt* design was the hope of reducing radar detectability from both surface and airborne radars. All other stealthy surface ships seem to be designed to deal primarily with surface radars, which look at them horizontally. It is enough, then, to surround open deck spaces with high, properly-shaped bulwarks. Behind the bulwarks is a reasonably conventional ship. However, any such ship still has a set of strong radar reflectors: her radar antennas. A conventional long-range radar needs a large reflecting antenna to create enough gain to pick up the weak signal of a target. It has to focus energy coming directly at it, which means it creates exactly

Zumwalt (DDG-1000) seen during a port visit to Pearl Harbor in April 2019. Note the mountings for satellite antennas on her superstructure, which somewhat negate efforts to maximise radar stealth. *(US Navy)*

Even if a ship can be designed to be entirely stealthy, her wake may be a giveaway to an observing airborne radar. This picture of NATO warships breaking formation during the NATO Dynamic Mongoose anti-submarine exercise in 2017 illustrates the point. *(NATO)*

The US Navy's *San Antonio* (LPD-17) class amphibious transport docks incorporate several measures aimed at enhancing stealth, notably the use of enclosed masts to shield reflections from their own radar arrays. However, it is notable that the feature has been dispensed with in the latest iterations of the design, which suggests its value may have been questionable. This is *Green Bay* (LPD-20) on deployment with the America Expeditionary Strike Group in the Philippine Sea in January 2020. *(US Navy)*

the wrong sort of structure for stealth. The great discovery seems to have been that a radome can be tuned to pass only a narrow frequency band, so that nearly all search radars looking at it will see only a smooth shape which reflects their pulses away. Many recent warships enclose their air-search radars in their masts. The most efficient enclosure is probably an inverted cone, but faceted enclosures seem far more common. A US example is the odd-looking masts of *San Antonio* (LPD-27) class amphibious ships, which also have characteristic canted and chined hulls, rather than the flat-sided ones of their predecessors.

The alternative is to eliminate the reflector altogether. A phased-array radar has no reflector at all. Typically its panels are tipped back from the vertical, so they reflect signals up, away from the observing radar. An active array has the additional merit of being able to null out a signal from any particular direction, reducing reflection even further. That is well known in the aviation world.

Satellite dishes are also strong reflectors, because like radar dishes or antennas they have to focus weak signals. It helps that they point up rather than more or less horizontally. In the extreme *Zumwalt* class a serious attempt was made to eliminate them in favour of flat arrays atop the ship's tower superstructure.

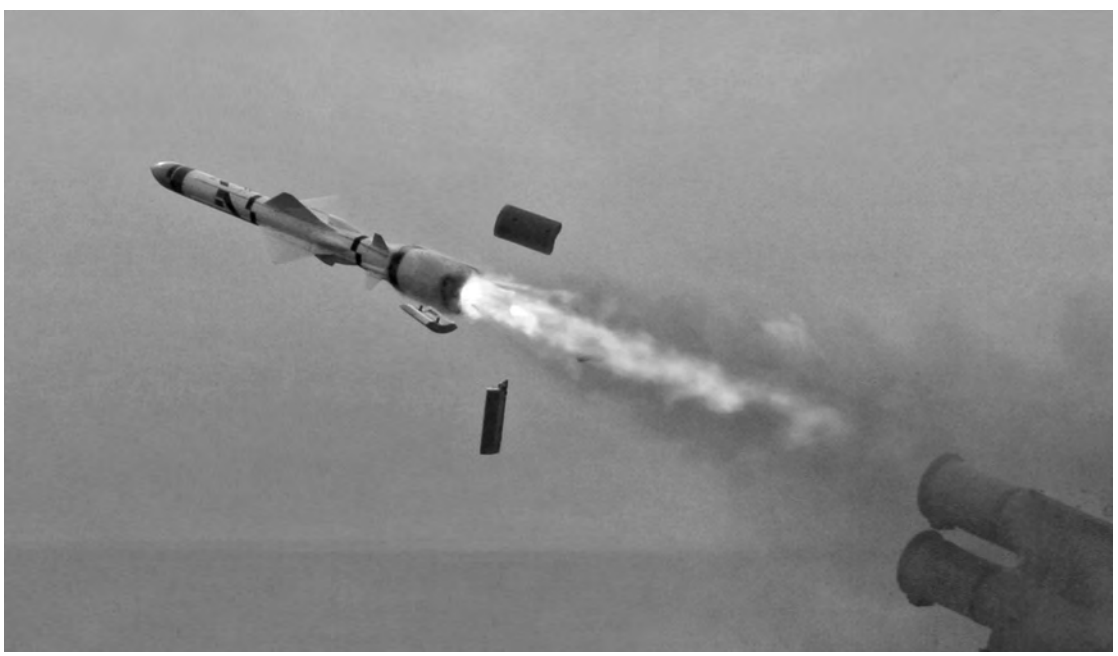
CURBING EMISSIONS

Stealth requires that all the emissions the ship produces be suppressed. That has an important potential tactical advantage. Missiles are generally fired beyond the shooter's horizon. It is difficult enough to identify targets at such ranges, but it seems even more difficult to know how badly (if at all) they have been damaged. Modern missiles generally lack the punch to sink large ships, although it is reasonable to imagine that they can cause disabling damage. If, as is often the case, the damage cannot be observed, how is the shooter to tell what has been achieved? The answer has to be to see whether the ship is still moving or still emitting. At long range the clues will be electronic emission and acoustics. If the ship is sufficiently silenced, acoustic clues will be very limited.

RADAR EMISSIONS

The ship's electronic emissions therefore become very important. To what extent can she keep emitting without being detected? In October 1990 Signaal (now Thales Nederland) revealed its stealthy Scout surface-search radar. It pointed out that radar detectors responded to the peak power of a radar pulse, but that radar range depended on average power. Radars spend very little of their time transmitting, so average power is far less than peak power. Instead of periodically emitting short powerful pulses, Signaal's radar emitted continuously, varying its frequency systematically. The frequency received gave the range of a target. Signaal sometimes described its low probability of intercept (LPI) radar as an FM device; conventional radars were AM devices, like AM radios. FM was more complicated

Low probability of intercept radar systems were pioneered by Signaal – now Thales Nederland – as a means of reducing a ship's emissions. This image of a Hellenic Navy *Roussen* class fast attack craft shows the company's Scout Mk 2 array on a forward projection from the mast below her main Thales MW08 3-D surveillance radar. *(Guy Toremans)*



Modern missiles such as the Exocet MM40 Block 3 are designed to supress emissions, thereby making it more difficult for electronic warfare countermeasures designed to combat their threat to be effective. *(MBDA/Michel Hans)*

than AM, but the dividend of invisibility was quite valuable. Scout used a conventional surface-search antenna, so no one could be sure of whether a particular ship had it on board.

Canadian Marconi pointed to a higher-powered application suitable for air-search radars. There were already many pulse-compression radars. They used long-duration pulses which the receiver converted into the equivalent of higher-powered short ones. Typically radar frequency changed during the pulse (a chirp), or the pulse consisted of sub-pulses with different phases. Pulse compression had been invented as a way of increasing average radar power (hence range) without encountering a serious problem, which was that powerful radar pulses could break down the air in a waveguide and so stop the radar signals. Canadian Marconi realised that this was analogous to what Signaal was doing in its Scout radar. Instead of using a powerful chirped pulse to produce the equivalent to a much more powerful short pulse, it could reduce the peak power of its long pulses. Maximum power could then be set below the threshold of a radar detector. Although Canadian Marconi did not sell many of its pulse-compression stealthy air-search radars, the idea caught on. That is apparent from current radar brochures. In the early 1980s it was common to see radar pulse data listed, because anyone with a radar detector could measure pulse durations and pulse rates. Once pulse compression became common, such data disappeared. Effective measurement now required much more information about the radar pulse pattern.

The Signaal radar used a frequency pattern set by the mechanism of the radar; it was relatively easy to make the frequency rise and fall regularly. Modern radars generally use broadband signal generators. A computer produces a waveform and selects a frequency, which can be changed rapidly over a fairly wide band. A modern stealthy radar will appear to emit weak – hence not easily detected – pulses varying randomly in frequency. This is called spread-spectrum emission, because the radar spreads its signal over a wide frequency spectrum. A modern radar detector is intended to seek spatial and time patterns it can exploit to identify them as radars. As in the case of radar stealth, it can be argued that future quantum computers would be particularly well adapted to doing that, because they would consider alternative correlations more or less simultaneously.

Not surprisingly, this battle is not conducted in public. It does, however, raise the question of how

Whilst not designed with a low radar cross section, the US Navy's *Spruance* (DD-963) destroyers incorporated measures such as rafted machinery and exhaust cooling to reduce acoustic and infrared emissions. This is *Kinkaid* (DD-965) in 2002. *(US Navy)*

effective missile countermeasures can be. These countermeasures are intended to confuse the incoming missile. To be able to do this, they have to detect its homing signal. To some extent, the process can be simplified if the ship's radars or IR sensors detect the missile in the first place, so that the countermeasures system can limit itself to emissions from the direction of the missile. However, the missile is likely to be somewhat stealthy. For example, the current Exocet MM40 Block 3 suppresses both its radar reflection and its IR signature. For the former, it uses a narrow-band antenna, which is already shaped to deflect radar signals. For the latter, it is subsonic – hence not inherently hot – and jet-powered, hence probably designed to mix cool air with its exhaust. It would be significantly more difficult to make a hypersonic missile stealthy, whatever was done to reduce its apparent radar emissions. Moreover, air transmits different infrared wavelengths very differently. The exhaust of a rocket missile can be doped to shift most of the radiation towards wavelengths that transmit poorly.

COMMUNICATIONS EMISSIONS

Radar stealth concepts carry over into communications. It seems impossible to conduct modern naval warfare without extensive radio communication. A communication transmitter is analogous to one-way radar. Modern ones often use spread-spectrum (frequency-varying) techniques to make them less detectable. In their cases the receiver has to be tuned to the pattern of frequency changes. Frequency-hopping is not a new idea; it was conceived during the Second World War but did not become practical until later. It requires synchronisation between sender and receiver, which in turn means precise clocks and time standards. The better the clocks, potentially the shorter the time between hops.

In theory, satellite communication should be stealthy: the ship transmits up, using a narrow-beam dish. However, the satellite down-link contains information which gives rough location data. Although the receiving satellite is, in theory, stationary in the sky, in fact it moves slightly. Nearly all satellite systems re-transmit their signals down, shifting them in frequency but preserving all features of the original up-link. A receiver which can measure frequency precisely can detect Doppler shifts in the up-link associated with a ship's position relative to the satellite. During the Falklands War, an Argentine reconnaissance plane – a Boeing 707 airliner – found the British fleet, apparently using this type of information (the technique had been developed by an Argentine university, and also by many others). Precision was similar to that achieved by long-range shore-based HF/DF. Later a British officer was able to track an amphibious group across the Atlantic in the same way, and apparently the Russians used the technique to track the build-up of Western forces in the Middle East prior to the 1991 Gulf War. The antidote is a much more elaborate satellite communication system, in which the content of the up-link is translated into a digital signal which is recoded for the down-link. It is not clear how widely such systems have been used. The remaining value of satellite stealth is that the link cannot be intercepted by nearby ships and aircraft.

ACOUSTIC EMISSIONS AND INFRARED

Acoustics is another source of detection. Gas turbines are inherently quiet. However, they spin at high speeds and therefore need gearing, which certainly is a source of detectable sound. This is much the situation with nuclear submarines. For example, US Navy and British Royal Navy nuclear submarines place their turbines and gears on rafts – resiliently mounted to the hull – to keep sound inside the submarine. In some cases there is also sound-absorbing covering (not to be confused with sound-absorbing anti-sonar covering intended to protect against homing torpedoes). Probably the first case of rafting in a surface ship was in the US Navy's *Spruance* (DD-963) class. In this case the building contract offered a bonus for silencing and the shipyard adopted special silencing measures to win it.

Diesels are inherently much noisier, but resilient mounting can still reduce that. Probably the first operational example was the British Royal Navy *Porpoise* class submarine design of the 1950s. When they were being designed, the new US SOSUS

France's *La Fayette* is popularly regarded as the world's first truly stealth warship. Her canted hull and clean lines are noticeable in this 2007 view. The Crotale surface-to-air missile system atop the hangar somewhat ruins the overall effect, the planned retrofit of an alternative VLS system having been abandoned. *(US Navy)*

One specific stealth feature incorporated in the *La Fayette* design is the concealment of the ship's boats in recesses in the superstructure; covered behind doors when not in use. This February 2015 view illustrates the arrangement. *(US Navy)*

Sound Surveillance System was detecting snorkelling submarines at ranges of hundreds of miles, but a *Porpoise* could not be detected beyond about 30 miles. Diesels can also be hooded to reduce their airborne noise. That was unimportant in submarines of the 1950s, but airborne noise is probably more important now. Typically it is dealt with by placing an acoustic hood over the engine. This is a long-understood technology.

Gearing can be eliminated altogether by adopting electric drive: the prime mover turns a generator, and a motor turns the propeller. The most prominent example of stealth achieved in this way is the British Type 23 'Duke' class frigate, which needed to be particularly quiet to operate its towed array at low speed. To that end it was given rafted diesels driving generators which could power its propeller (at higher speeds the ship used a more conventional gas turbine). At least in theory, an electric power plant can also be more resistant to battle damage, because there can be multiple paths between generator and motor. In addition, there can be multiple generators in various places in a ship, both above and below the waterline.

Ships themselves of course have infrared (IR) signatures, particularly due to the plumes of their engine exhausts. These plumes are far hotter, hence far more visible, for gas turbines than for diesels. This has resulted in various measures to dissipate the IR signature by cooling the plume and/or the structure of the exhaust. US Navy efforts in this direction are evident, for example, in the exhausts of the *Spruance* class.

STEALTH IN SERVICE

The first warship class commonly regarded as being fully stealthy are the French *La Fayette* class frigates. An initial batch of three of an eventual class of five ships was ordered in March 1998; *La Fayette* was commissioned in 1996. Designed with an eye for 'presence' missions in France's overseas territories and the Francophone world, they have provision for a covered assault boat in the stern but are not equipped with sonar for anti-submarine duties. Stealth features are very noticeable. The hull side is canted outwards (at about 10 degrees) over the ship's whole length rather than, as in previous designs, only fore and aft. The line between the canted side and the vertical is at the top of the hull; note that in many more recent stealthy designs this is considerably lower, because it is still sufficient to break the

The US Navy Littoral Combat Ships *Montgomery* (LCS-8) and *Gabrielle Giffords* (LCS-10) seen operating together in the South China Sea in January 2020. The design shows particular attention to radar stealth. *(US Navy)*

corner formed by the vertical side and the sea. Less obviously, the ship is stabilised. This is not only a matter of comfort; it also maintains the angle between the ship's side and the sea so as to avoid creating a corner reflector. Fin stabilisers are complemented by a rudder roll-control system.

The flat face of the *La Fayette*'s bridge is tipped back at a slight but sufficient angle, to reflect horizontal radar beams up instead of back towards the radar. The bulwark around the base of the single gun shields the demarcation between superstructure and fore deck. The bow anchor is exposed; presumably because it adds little to radar cross section. Boats are concealed behind doors amidships; otherwise their spaces would create corner reflectors. The 100mm gun mounting forward has faceted sides (to reflect pulses away) and its base is covered by a bulwark reflecting signals away from any observing radar. A bulwark also covers most of the length of the Exocet anti-ship missile launchers installed atop the superstructure. The superstructure is unusually clean and both it and the masts are covered in radar-absorbing paint. The forecastle and quarterdeck are covered with radar-absorbent cladding. For silencing, the ship's diesels are mounted on rafts. Gearing is avoided by using controllable-pitch propellers.

La Fayette has directly influenced many following designs, not least in Europe. For example, the more recent FREMM frigates show many of the same stealth features. However, their chine is lower down and the French variant incorporates an angled cover for its 3-D Heracles radar. As previously mentioned, the lower chine line is now typical. Stealth is enhanced by using vertical launchers sunk into their decks, which are now also very common. Another recent European frigate design incorporating a range of stealth features are the German F125 stabilisation frigates. These include a full-length hull chine, a faceted superstructure and enclosed boat hangars. The upper hull and superstructure have a stealthy 'X' form cross section also seen in other recent German warship classes.

Turning to the United States, the *Independence* (LCS-2) class Littoral Combat Ship design seems to show particular attention to stealth, for example by adopting a canted and tined hull and a conical enclosure for the air-search radar. However, ships of the class do carry two prominent satellite radomes – which may be stealthy – and the usual Phalanx radar dome for Sea RAM. Similarly the alternative *Freedom* (LCS-1) class incorporates a canted hull and superstructure, albeit the superstructure is seemingly more cluttered and, perhaps, less stealthy.

Many other ships have stealthy chined hulls but their superstructures seem not to show the necessary attention to detail, and they may not be stealthy at all. However, their basic shape may well make them amenable to improvements which would dramatically reduce their radar cross sections.

Notes

1. Note, however, that by the end of the Cold War some of the large Soviet missiles employed missile-to-missile data links. At the time, they merely allowed one missile to act as a scout for a salvo, flying above it to distinguish targets and allow the others to fly below enemy radar before locking on. At least in theory, future anti-ship missiles could work together to exploit gaps in a ship's stealth. For this to work, the missiles would have to know where they were. However, GPS has solved that problem.

2. Cynics pointed out that in the Gulf F-117s never flew alone; they were always accompanied by jammers. However, the subsequent 1999 shoot-down over Serbia was not attributed to any failure of stealth, but rather to a failure of common sense: the aircraft not only flew in daylight (hence could be seen) but also kept flying exactly the same path every day. It was brought down by a command-guided missile, exactly the type which could be coached into position visually, without relying on radar.

3. No one seems to have realised how expensive the necessary long-range guided 155mm shells would be. They have died.

4. Probably the most important goals of the project, as conceived, were very low manning and low fuel consumption. Low manning was wanted because so much of the naval budget is spent on personnel. The ship's integrated electric power plant offers inherently low fuel consumption, as well as a degree of greater survivability.

5. Hence the US decision to prohibit the sale of F-35s to Turkey after that government decided to buy Russian air defence systems, whose radars could have been tested against the F-35s. At the least, stealthy aircraft usually produce substantial radar returns in some directions, and tests would make it possible to map them.

6. During the period of the no-fly zone over Iraq, the Iraqis tried to create just such a system, the radars being tied together by fibre-optics. The system was bombed to deny Iraq this capability.

4.3 TECHNOLOGICAL REVIEW

A QUIVER OF ARROWS

The Standard Missile family continues to evolve

Author:
Richard Scott

Originally conceived as the US Navy's primary medium-to-long range fleet anti-air missile system, the Standard Missile line has been continuously evolved and adapted over a near-60 year period to address new threats and emergent operational needs.[1] This has resulted in a family of high performance, all-weather guided weapons engineered to meet a diverse range of anti-air warfare (AAW), ballistic missile defence (BMD) and anti-surface strike missions. Over 25,000 Standard Missile all-up-rounds have been delivered to date, with three distinct marques currently in production.[2]

Although the aerodynamics of the Standard Missile have changed relatively little over time, the evolution of the guided weapons system has seen various new technologies and techniques introduced to impart improvements in kinematic performance, guidance and control, communications, terminal homing, fuzing and warhead effect. While not every derivative development has ultimately entered service, the programme's incremental approach to systems engineering has, to a greater extent, realised significant benefits with regard to cost, risk, weapon system integration and inventory management.[3]

The *Arleigh Burke* class destroyer *Benfold* (DDG-65) fires a Standard Missile-2 (SM-2) at a target drone as part of a surface-to-air-missile exercise in September 2016. Currently in production in three distinct marques, the Standard Missile is an integral part of the Aegis Weapon System equipping the US Navy's *Ticonderoga* (CG-47) class guided-missile cruisers and *Arleigh Burke* (DDG-51) class guided-missile destroyers. *(US Navy)*

STANDARD MISSILE PRODUCTION HERITAGE

The production lifespan of the Standard Missile line has seen significant changes in the development, manufacture and acquisition of its many variants, mirroring wider change and consolidation within the US guided weapons sector.

The Standard Missile traces its lineage to the RIM-2 Terrier (extended range) and RIM-24 Tartar (medium range) guided weapons previously developed by General Dynamics' Pomona Division for the US Navy. Terrier and Tartar were themselves directly derived from the Bumblebee Program established towards the end of the Second World War to nurture the development of guided weaponry for fleet air defence.

Development of the Standard Missile, conceived in both medium and extended-range variants to replace Tartar and Terrier, commenced in October 1963 at the instigation of the Surface Missile Systems Project Office. The technical foundation for the respective programmes lay with the Improved Tartar retrofit and the Homing Terrier 3 programmes. Indeed there was significant component and almost complete aerodynamic commonality between the new SM-1(ER) and SM-1(MR) rounds and their progenitors. The first iterations of the SM-2 were subsequently developed in the 1970s, being deployed on board the first Aegis-equipped ships and those receiving the New Threat Upgrade (NTU).

General Dynamics' Pomona Division was the sole-source designer and supplier of the Standard Missile until 1988. Production was then dual-sourced, with contracts split between General Dynamics' missile business (acquired by Hughes in August 1992 and subsumed within Hughes Missile Systems Company) and Raytheon. The latter was also given responsibility as prime contractor and round design agent for the development of the SM-2 Block IV missile.

In 1995, with production numbers declining in the post-Cold War era, Hughes and Raytheon established the Standard Missile Company, a limited-liability company for the purpose of developing and producing all versions of the Standard Missile. A dedicated headquarters facility was established in McLean, Virginia, to manage contracts and systems engineering and to control contractor design engineering. The company, in turn, subcontracted work to Hughes, Raytheon and other qualified subcontractors.

With the acquisition of Hughes Missile Systems by Raytheon in 1997, the joint venture framework became redundant and the Standard Missile Company was dissolved a year later. What is now Raytheon Missiles & Defense (established in April 2020 following the merger of Raytheon and United Technologies to form Raytheon Technologies) is now sole contractor and design agent for the Standard Missile line.

SM-2 all-up-round production has now restarted at the company's facility in Tucson, Arizona. Final assembly of the SM-3 and SM-6 missiles takes place at Raytheon Missiles & Defense's production facility at Redstone Arsenal in Huntsville. This facility opened in November 2012.

Two images of a Standard Missile-3 (SM-3) variant in the final stages of assembly at Raytheon Missiles & Defense's production facility at Redstone Arsenal in Huntsville, Alabama. Raytheon Technologies is now sole contractor and design agent for the Standard Missile line. *(Raytheon)*

AREA AIR DEFENCE: STANDARD MISSILE-2

The RIM-66 Standard Missile-2 (SM-2) remains the US Navy's primary medium-range weapon against aircraft and anti-ship cruise missiles. A solid-propellant-fuelled, tail-controlled surface-to-air missile launched from the Mk 41 vertical launcher system, it is an integral part of the Aegis Weapon System equipping the service's *Ticonderoga* (CG-47) class guided-missile cruisers and *Arleigh Burke* (DDG-51) class guided-missile destroyers.

In an Aegis engagement, the ship's AN/SPY-1(V) radar detects and tracks a target and the combat system relays target positional information to the SM-2 missile. Following launch, the missile manoeuvres to bring itself onto the desired flight path, receiving mid-course updates via an S band (NATO E/F band) uplink in order to refine its intercept course as it closes to the target. Terminal phase X band (NATO I/J band) illumination for the missile's monopulse semi-active radar seeker is provided by the AN/SPG-62 illuminators on the Aegis ship. Maximum range is publicly declared as 90 nautical miles.

As of 2020, the US Navy has the Block III, Block IIIA and Block IIIB variants of SM-2 in its inventory. Development of the Block III all-up-round was initiated in 1984, building on the earlier RIM-66G/J Block II missile (this had introduced the 13.5in (343mm) diameter Mk 104 Dual Thrust Rocket Motor (DTRM) to increase range and improve performance against faster and more manoeuvrable targets, all-digital signal processing and the Mk 115 high-velocity fragmentation warhead). Block III retained these features but incorporated improved electronics and a Mk 45 Mod 8 Target Detection Device (TDD) to enhance performance against low-altitude targets. Full production approval for SM-2 Block III came in June 1988.

The SM-2 Block IIIA round was approved for full production in February 1992, and achieved initial

operational capability in January 1994. Block IIIA incorporates the Mk 125 warhead (which imparts greater velocity to warhead fragments in the direction of the target) and the Mk 45 Mod 9 TDD to enhance capabilities against sea-skimming targets. To meet the needs of the Netherlands/German/Canadian Trilateral Frigate Cooperation Anti-Air Warfare System (TFC-AAWS), a specific hardware/software modification was developed to enable the SM-2 Block IIIA missile to operate in the Interrupted Continuous Wave Illumination (ICWI) guidance mode. ICWI uses mid-course guidance and sampled data homing: a digital rear receiver allows the SM-2 Block IIIA missile to synchronize in time and frequency with waveforms transmitted by the Thales APAR X-band multifunction radar (MFR) associated with TFC-AAWS. All Block IIIA rounds manufactured from 2000 onwards have come off the production line with the ICWI modification embodied.

Block IIIA was followed into US Navy service by the dual-mode SM-2 Block IIIB round which introduced a side-mounted adjunct infrared sensor, developed under the Missile Homing Improvement Program, to complement the semi-active radar homing channel and improve endgame performance against the most difficult targets. Missile guidance logic was expanded to synthesise information from the ship and from both missile seekers: once the missile has evaluated the information from each seeker it decides which one to use for guidance to the target. Block IIIB achieved initial operational capability in 1997, and serves as the basis for the Aegis low-altitude capability. A software-based manoeuvrability upgrade has been developed and implemented to enhance Block IIIB performance against low-altitude, supersonic manoeuvring threats.

In 2001 Raytheon was contracted for the development of the Mk 45 Mod 14 TDD. Designed to improve lethal radius at low altitudes, the Mod 14 TDD incorporates a solid-state Radio Frequency (RF) device and a new programmable signal-processing architecture enabling future upgrade by software. Raytheon began delivering Block IIIA and Block IIIB missiles fitted with the Mk 45 Mod 14 TDD from new in late 2008.

A further SM-2 variant, known as Block IIIAZ, has been developed as a specific adaptation engineered for compatibility with the navy's three *Zumwalt* (DDG-1000) class destroyers. The SM-2 Block IIIAZ modification kit embodies hardware and software changes to existing Block IIIA missiles to enable compatibility with the DDG-1000's non-Aegis combat system, AN/SPY-3 MFR, X-band Joint Universal Waveform Link and ICWI guidance functionality.

In FY2011 the US Navy elected to cease SM-2 production buys having reached its inventory objective. However, the service – through the Program Executive Office Integrated Warfare Systems – and

The destroyer *Mustin* (DDG 89) fires an SM-2 missile. The SM-2 has been subject to ongoing improvements in the form of various Block iterations since first introduced into operational service at the start of the 1980s and remains in production for overseas navies. *(US Navy)*

The RIM-66 Standard Missile-2 (SM-2) remains the US Navy's primary medium-range weapon against aircraft and anti-ship cruise missiles. An SM-2 improvement programme – resulting in a Block IIIC iteration using a new guidance and homing section incorporating a dual mode radar seeker – is currently being developed. Here *Stout* (DDG-55) fires a current SM-2 version during a missile exercise in the Atlantic in September 2019. *(US Navy)*

Raytheon had always anticipated that, given continued international demand for SM-2 missiles sold government-to-government through Foreign Military Sales (FMS), the gap in production would be temporary. Outside of the US Navy, SM-2 variants are in service with the navies of Australia, the Republic of China (Taiwan), Germany, Japan, the Republic of Korea, the Netherlands and Spain. The challenge for the re-start programme was to achieve alignment between the offtake requirements and budgetary cycles of multiple navies so as to aggregate an economical production volume. Following a number of years of planning activity, the SM-2 re-start was formalised in a June 2017 contract award to Raytheon covering the production of 282 SM-2 Block IIIA and Block IIIB missiles for the governments of Australia, Japan, the Republic of Korea, and the Netherlands.

Deliveries of new-build SM-2 all-up-rounds have now recommenced following a successful flight test performed at the White Sands Missile Range in New Mexico in February 2020. A second batch-buy for FMS customers is currently in planning.

In parallel to the re-start activity, the US Navy has developed plans for an SM-2 improvement programme which will see the introduction of a new guidance and homing section incorporating a dual mode (active/semi-active) radar seeker.[4] This will result in the introduction of a new variant, known as Block IIIC, providing a medium-range active capability. To realise the full medium-range active capability, the SM-2 Block IIIC missile will also feature modifications to missile hardware and guidance/navigation control functionality. Another activity being performed as part of the SM-2 improvements programme is an Insensitive Munitions effort to introduce a single pulse electronic ignition safety device for the MK 104 DTRM.

In December 2018, the United States' Naval Sea Systems Command (NAVSEA) awarded Raytheon a c. US$149m contract for SM-2 Block IIIC engineering and manufacturing development. Block IIIC production is scheduled to begin in FY 2021.

A specific hardware/software modification was introduced in SM-2 Block IIIA missile rounds produced from 2000 onwards to enable the missile to operate in the Interrupted Continuous Wave Illumination (ICWI) guidance mode in conjunction with the Thales APAR radar. The Royal Netherlands Navy's *De Zeven Provinciën* – pictured here during a trial SM-2 firing – is one of the ships to benefit from this modification. *(Royal Netherlands Navy)*

NAVY AREA THEATRE BALLISTIC MISSILE DEFENCE

Development of the RIM-156A SM-2 Block IV (otherwise known as Aegis ER) missile was initiated in 1987. It was conceived during the Cold War to meet requirements for a missile able to engage reduced-signature, high-speed manoeuvring targets from sea-skimming to very high altitudes against a background of severe electronic countermeasures. The US Navy publicly declared a range of 100–200 nautical miles. Designed to achieve substantially improved kinematic performance (cross range, down range and very high altitude) over earlier iterations, Block IV incorporated a modified airframe, a slip cast fused silica radome and new flight control surfaces, a low side-lobe antenna, low noise receiver and dual digital signal processor, a digital autopilot and a Mk 72 Thrust Vector Control booster.

At-sea firings, conducted in July and October 1994 from the cruiser *Lake Erie* (CG-70), demonstrated the Block IV missile's area and self-defence capabilities against a range of targets. However, SM-2 Block IV production was limited to 100 missiles as the navy looked instead to develop a Block IVA missile which, as part of the nascent Navy Area Theater Ballistic Missile Defense (TBMD) system, could confer an endo-atmospheric intercept capability against ballistic missile threats while at the same time retaining existing Block IV AAW performance.

The Navy Area TBMD system was designed to combine a modified Aegis Weapon System, the AN/SPY-1 radar (adapted to enable detection and tracking of faster, higher-flying and longer-range missiles and their warheads) and the SM-2 Block IVA missile. The primary modifications introduced for Block IVA were the integration of a side-mounted mid-waveband imaging infrared seeker (IIR) for improved terminal homing, an active RF adjunct sensor providing additional measurements for fuzing, and a forward looking fuze. Other modifications included new guidance and control algorithms, an improved inertial measurement unit, a new digital autopilot, the Mk 125 Mod 1 fragmentation warhead and greater battery capacity. The Block IV propulsion stack (Mk 72 booster/TVA and Mk 104

DTRM) and steering control section were retained.

The US Navy and the Ballistic Missile Defense Organization – subsequently to become the Missile Defense Agency (MDA) – conducted a risk reduction flight test from the 'Desert Ship' facility on White Sands Missile Range in New Mexico in January 1997. The trial intercept, using an SM-2 Block IV round converted to prototype Block IVA standard, successfully intercepted a Lance TBM target. Engineering and Manufacturing Development of Navy Area TBMD subsequently began in March 1997. However, the programme was abruptly cancelled in December 2001 by the MDA owing to schedule slippage and cost escalation resulting from difficulties in integrating the IIR sensor, the RF adjunct sensor and the associated forward looking fuze. These unresolved fuzing problems led to unacceptable miss distances in simulations.

'LEAP' TO STANDARD MISSILE-3

The beginnings of the RIM-161 Standard Missile-3 (SM-3) go back to the early 1990s and the experimental Terrier Lightweight Exo-Atmospheric Projectile (LEAP) project. Following the 1991 Gulf War – during which US ground forces came under attack from Iraqi 'Scud' missiles – the US Navy completed four flight tests of Standard Missile Block III ER Terrier missiles modified to deploy a kinetic-kill vehicle deployed from a third stage between 1992 and 1995. Two of the test firings were performed against Aries theatre ballistic missile targets representative of a 'Scud' type missile. Neither achieved a successful intercept. However, the navy was encouraged by the flight-test results from LEAP and went on to pursue the Aegis LEAP Intercept (ALI) flight demonstration project, which itself became a risk-reduction demonstration for the Navy Theater Wide (NTW) TBMD system.

Capitalising on the existing Aegis Weapon System, and a suitably modified AN/SPY-1(V) radar, NTW was conceived to provide regional protection for US and allied forces deployed overseas, providing coverage for critical infrastructures (such as airfields and ports) and large population centres. The SM-3 missile was developed to provide an exo-atmoshperic intercept capability for NTW.

The three-stage SM-3 missile uses the same

The guided-missile cruiser *Lake Erie* (CG-70) pictured departing Pearl Harbor in August 2014. The cruiser was involved in demonstrating the short-lived Block IV iteration of the SM-2 missile's area and self-defence capabilities against a range of targets in the mid-1990s. *(US Navy)*

Mk 72 booster and Mk 104 DTRM as the SM-2 Block IV missile, but the warhead and guidance section of the SM-2 are replaced by a Mk 136 Third Stage Rocket Motor (TSRM) and associated guidance section, and an exo-atmospheric Kinetic Warhead (KW). The purpose of the three-stage propulsion stack is to deliver the KW to a point in space from which it can acquire, track, and use its own divert propulsion system to control its own course to achieve a hit-to-kill intercept. Separating from the third stage approximately 30 seconds before intercept, the KW impacts the target with more than 130 MJ of kinetic energy – the equivalent of a 10-ton truck travelling at 600 miles per hour.

The SM-3 flight sequence is described thus. Following launch, the missile pitches over to align its velocity vector with the initialised commands downloaded prior to launch. The AN/SPY-1(V) radar associated with the Aegis Weapon System acquires and tracks the missile beacon during this phase. Following separation of the Mk 72 booster, and the ignition of the Mk 104 DTRM, the Aegis Weapon System uses an uplink to transmit acceleration commands to the SM-3. The mid-course guidance law aligns the missile velocity vector with the reference vector pointing at the predicted missile/target intercept point (GPS is an integral element of the SM-3 guidance system).

At burnout, the second-stage Mk 104 DTRM separates from the missile assembly. The third-stage (exo-midcourse) Mk 136 dual-pulse TSRM now takes over to increase velocity at atmospheric exit. During this phase, the third-stage guidance section receives an uplink message providing updated target state vector data (position and velocity) from the Aegis Weapon System, which is merged with GPS-based missile-developed guidance. The third stage uses burnout reference guidance, calculated on the missile, to steer during the TSRM burn. Missile and target positions at burnout are predicted, and steering commands to place the two on a collision course are used by the TSRM. The missile is thrust vector-controlled during both TSRM 10-second pulse burns: at the appropriate time-to-go to intercept, the KW is initialised and released.

The KW for the SM-3 missile is derived from LEAP. The full vehicle assembly comprises a staring longwave infrared seeker; a guidance assembly (incorporating signal and data processing, an inertial measurement unit, a thermal battery, and a telemetry transmitter), a pulsed Solid Divert and Attitude Control System (SDACS) propulsion assembly, and an interface and ejector mechanism. Following the ejection of the KW from the third stage, the SDACS is ignited and the vehicle orientates along the predicted line of sight to the target. The seeker then acquires and tracks the target, employing a predicted impact guidance law for an intercept solution, and using the SDACS to execute homing manoeuvres.

A graphic dating from 2011 showing the main constituent parts of the Standard Missile-3 Block 1A and Block 1B variants. The three-stage SM-3 missile uses the same Mk 72 booster and Mk 104 DTRM as the SM-2 Block IV missile, but the warhead and guidance section of the SM-2 are replaced by a Mk 136 Third Stage Rocket Motor (TSRM) and associated guidance section, and an exo-atmospheric Kinetic Warhead. *(Missile Defense Agency)*

A first SM-3 controlled flight test was performed in September 1999 as part of the ALI programme. Flight tests conducted in January 2002 and June 2002 both resulted in the successful intercepts of Aries target missiles. The initial production version, Block IA, was first fielded by the US Navy in 2006 as part of the Aegis BMD capability (the naval component of the US Ballistic Missile Defense System). This realisation of the SM-3 interceptor programme provided a capability for mid-course engagements of short-range ballistic missiles.

A further developed SM-3 Block IB variant became operational in 2014. In this variant, the KW incorporates a two-colour infrared seeker and an improved signal processor to improve target discrimination. Another change is the introduction of a Throttleable Divert Attitude Control System (TDACS) developed by Aerojet Rocketdyne: TDACS brings the ability to dynamically vary thrust and operating time, so imparting improved manoeuvrability in the terminal phase of the hit-to-kill engagement.

Outside of the US Navy, the Japan Maritime Self-Defense Force has introduced the SM-3 missile as part of the Aegis BMD capability deployed on its four *Kongou* class and two *Atago* class Aegis guided-missile destroyers. Japan has acquired both SM-3 Block 1A and SM-3 Block 1B missiles. To date, over 400 SM-3 interceptors have been delivered to the

STANDARD MISSILE-3 EVOLUTION
PHASED ADAPTIVE APPROACH
PHASE 1 (2011)
CURRENTLY DEPLOYED
INITIAL CAPABILITY AGAINST SRBMs, MRBMs AND IRBMs
PHASE 2 (2014)
CURRENTLY DEPLOYED
ROBUST CAPABILITY AGAINST SRBMs, MRBMs AND IRBMs
PHASE 3 (2018)
IN TESTING
ROBUST CAPABILITY AGAINST SRBMs, MRBMs AND IRBMs
1,000 KM
3,000 KM
5,500 KM
5,500+ KM
• SEA-BASED
• MORE THAN 130 DELIVERED
• SEA- AND LAND-BASED
• ADVANCED STEERING AND DISCRIMINATION
• SEA- AND LAND-BASED
• IMPROVED VELOCITY AND RANGE
SM-3 IA
SM-3 IB
SM-3 IIA
SHORT-RANGE BALLISTIC MISSILE (1,000 KM OR LESS)
MEDIUM-RANGE BALLISTIC MISSILE (1,000 TO 3,000 KM)
INTERMEDIATE-RANGE BALLISTIC MISSILE (3,000 TO 5,500 KM)
Raytheon
Customer Success Is Our Mission
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A Raytheon graphic dating to late 2014 showing the proposed evolution of the Standard Missile-Insert 3 as used in the European Phased Adaptive Approach being implemented to provide Europe with a US-supplied missile defence shield. The 2018 in-service date of the Block IIA variant has proved to be a little optimistic. *(Raytheon)*

US and Japanese navies. More than thirty successful intercepts have been achieved in space against representative targets.[5]

In August 1999 the US and Japanese governments signed a memorandum of understanding for co-operative research and development on what was then known as NTW Block II. Under this memorandum, it was agreed that major components of a further developed SM-3 missile would be developed by Japan as part of a co-operative development.

Raytheon and Japan's Mitsubishi Heavy Industries began development of the SM-3 Block IIA interceptor to defeat medium and intermediate-range ballistic missiles in 2006. This new interceptor – 21in (533mm) in diameter compared to the 13.5in (343mm) diameter of previous SM-3 variants – has two major discriminators: first, a larger second and third stage rocket motor that allows for a higher burnout velocity, enabling the interceptor to travel further and intercept missiles travelling at higher speeds; second, an enhanced KW that improves search, discrimination, acquisition and tracking functions.

SM-3 Block IIA conducted its first two flight tests in 2015. In February 2017 Japan and the United States conducted a first successful Block IIA intercept test from the US Navy guided-missile destroyer *John Paul Jones* (DDG-53).[6] The next two tests, in June 2017 and January 2018, both resulted in non-intercepts. However, in October 2018 an SM-3 Block IIA missile launched from the destroyer *John Finn* (DDG-113) – equipped with the Aegis Baseline 9.C2 weapon system – successfully intercepted a target launched from the Pacific Missile Range Facility at Kauai, Hawaii. A further successful test was conducted in December 2018 from the Aegis Ashore Missile Defense Test Complex on Kauai, Hawaii. On this occasion, the SM-3 Block IIA intercepted an intermediate-range ballistic missile target as part of a live-fire test demonstrating Aegis Weapon System Engage On Remote. This capability allows the SM-3 interceptor to be launched using track data networked from remote sensors.

The MDA plans to test the SM-3 Block IIA missile against an intercontinental ballistic missile-class target before the end of 2020.

EXTENDING OVER-THE-HORIZON: STANDARD MISSILE-6

Development of the RIM-174 Standard Missile-6 (SM-6) was approved in 2004 to meet the US Navy's

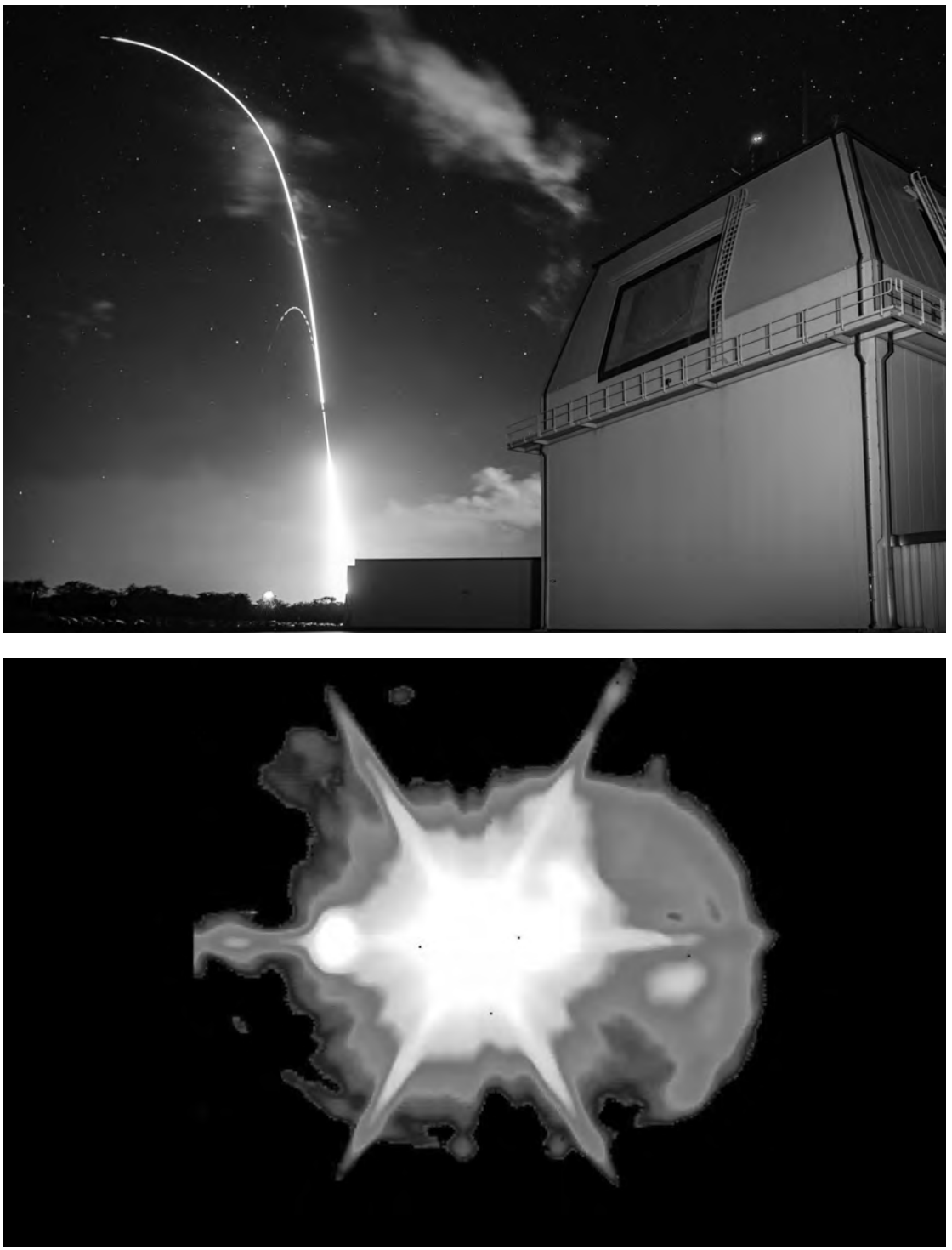
requirement for an over-the-horizon AAW missile able to engage aircraft, unmanned aerial vehicles, and land-attack/anti-ship cruise missiles in flight, both over sea and land. It was envisaged that the full performance envelope of this Extended Range Active Missile would be realised as part of an integrated fire control network – known as Navy Integrated Fire Control-Counter Air (NIFC-CA) – that would provide the targeting and communications necessary to prosecute targets at very long range (publicly stated to be beyond 200 nautical miles).

The SM-6 design philosophy was conceived to be evolutionary and low risk, marrying the airframe and propulsion stack of the SM-2 Block IV missile with new or repurposed guidance and signal processing technology. The engineering approach also had in mind to allow for incremental updates to add additional capability over time.

Accordingly, the SM-6 all-up-round retains much proven Standard Missile hardware, notably the Mk 72 Mod 1 rocket booster, the steering control system, the Mk 104 Mod 3 DTRM, the Mk 125 warhead, and the airframe itself. Where it principally differs is in the introduction of a new mission computer, and a dual-mode (active/semi-active) X-band seeker based on that used in the AIM-120C-7 AMRAAM air-to-air missile. This new front-end electronics section interfaces to legacy Standard Missile functions – such as the datalink, inertial measurement unit, TDD and steering-control system – and re-hosts missile guidance and control functions.

Operation in the active mode eliminates the need for a shipborne illuminator, so providing for an improved capability against salvo attacks. The SM-6 missile also delivers the kinematic performance required to defeat current and projected threats that possess low-altitude, high-altitude, high-velocity and manoeuvre characteristics at the maximum range of the missile.

The SM-6 Block I missile achieved initial operational capability in November 2013. Operating in conjunction with the Aegis Weapon System, the SM-6 missile can be fired on target data organic to the launch ship. As a component of NIFC-CA – and operating with Aegis Baseline 9 – SM-6 can additionally use Cooperative Engagement Capability and remote sensor data of appropriate quality so as to function as a 'net-enabled' interceptor able to 'engage on remote'. In NIFC-CA engagements at long range or over-the-horizon, the SM–6 active seeker performs independent endgame intercept.



A Standard Missile-3 (SM-3) Block IIA launched from the Aegis Ashore Missile Defense Test Complex at the Pacific Missile Range Facility at Kauai, Hawaii, successfully intercepts an intermediate-range ballistic missile target in space on 10 December 2018. This was the third successful intercept out of five intercept tests for the SM-3 Block IIA missile. *(US Army)*

The *Arleigh-Burke* class guided-missile destroyer *John Paul Jones* (DDG 53) launches a Standard Missile-6 (SM-6) during a live-fire test of the ship's Aegis Weapons System in June 2014, a few months after the new weapon achieved initial operational capability. Over the course of three days, the crew of *John Paul Jones* successfully engaged six targets, firing a total of five missiles: four SM-6 variants and one Standard Missile-2 (SM-2). *(US Navy)*

Alternatively, within the shipboard radar envelope, SM-6 can be supported by the Aegis fire-control system (using shipboard illuminators) to consummate an engagement in semi-active mode.

In September 2016, the US Navy conducted an at-sea flight demonstration of the NIFC-CA Increment I capability at the Pacific Missile Test Center, California. The SM-6 Block 1 missile, fired from the cruiser *Princeton* (CG-59), destroyed an over-the-horizon target: this is claimed to have been the longest range surface-to-air intercept of its kind in naval history, although neither the US Navy nor Raytheon will divulge details of the exact range achieved

SEA-BASED TERMINAL INTERCEPTION AND ANTI-SURFACE ROLES

In the wake of the cancellation of the SM-2 Block IVA missile, seventy-five existing SM-2 Block IV missiles (introducing changes to the fuze and autopilot) were modified to provide a stopgap capability pending the introduction of a Sea-Based Terminal (SBT) interceptor. Subsequently, the decision was taken to adopt the SM-6 missile as the effector to be employed by Aegis BMD ships in the SBT role.

Missiles enabled for both AAW and SBT missions are designated SM-6 Dual I. SBT Increment 1 – introducing functionality to enable the SM-6 Dual I missile to defeat short-range ballistic missile threats inside the atmosphere in their terminal phase – provided the first evidence of how a software upgrade could realise additional capability. The SM-6 Dual I was entered in the MDA's Operational Capability Baseline in December 2015.

Meanwhile, in February 2015, the then US Secretary of Defense Ash Carter confirmed that the US Navy was developing a modification to SM-6 enabling an over-the-horizon anti-shipping strike role. Just under a year later, on 18 January 2016, the Navy Integrated Fire Control – Collateral demonstration at the Pacific Missile Range Facility proved this capability when an SM-6 missile successfully

The Standard Missile-2 has a secondary anti-ship capability, seen here being exercised by the *Arleigh-Burke* class guided-missile destroyer *Mustin* (DDG-89) in the course of a SINKEX against the former tank landing ship *Fresno* (LST-1182) in September 2014. In January 2016, her sister *John Paul Jones* (DDG-53) demonstrated the SM-6 had a similar capability successfully engaging the hulk of the former frigate *Reuben James* (FFG-57). *(US Navy)*

engaged and hit the hulk of the former frigate *Reuben James* (FFG-57). The primary purpose of the test, conducted from the destroyer *John Paul Jones* (DDG-53), was to validate that the legacy anti-surface capability of the Aegis Weapon System and the SM-2 missile had been successfully carried forward into the latest Aegis Baseline 9 with the SM-6 missile. Few details of the SM-6 surface mode test were disclosed, beyond the fact that the missile modifications were limited to software changes only, and that another DDG-51 destroyer was on station as the 'assist ship' for the engagement. No information was released regarding engagement range or flight profile.

Upgrades to the SM-6 line are already in train, beginning with the Block 1A missile. SM-6 Block 1A embodies engineering changes to the guidance section, including a GPS receiver, and modified software. The introduction of GPS improves coordinate frame alignment (an important consideration given the speed and distance that the missile travels and the threats it is engaging). SM-6 Block IA achieved initial operational capability in October 2019.

Plans for a SM-6 Block IB missile were publicly acknowledged in the navy's FY 2020 budget request. While little has been publicly released on this derivative, testimonies and presentations made by senior US Navy officers have left little doubt that the Block IB variant will be primarily roled for long-range strike. Conceived in response to urgent operational needs, SM-6 Block IB marks a significant departure in that it proposes to graft a new 21in (533mm) solid rocket sustainer onto the existing Block 1A guidance section to increase velocity and extend range. Other changes include a new steering control section and modified control surfaces.

Notes

1. The introduction of the name Standard Missile reflected a desire to develop largely common medium-range and long-range guided weapons that minimised compatibility changes and were produced to a 'standardised' design.

2. Space precludes a full account of the evolution of Standard Missile family and its antecedents. For a detailed history, see Matthew Montoya, 'Standard Missile: A Cornerstone of Navy Theater Air Missile Defense' Matthew Montoya, in *Johns Hopkins University Applied Physics Laboratory Technical Digest,* Vol 22 No 3 (Baltimore MA: John Hopkins University APL, 2001).

3. SM-4 was the RGM-165 Land Attack Standard Missile (LASM), which integrated a Global Positioning System/Inertial Navigation System (GPS/INS) guidance section into a SM-2 airframe together with a modified warhead, a Height-Of-Burst sensor, and a low-drag nosecone. LASM concept demonstration flights were completed in 1997–8, but the programme – which would have involved the conversion of existing SM-2 Block II/III missiles – was cancelled in 2002. The designation SM-5 was associated with a late 1990s US Navy plan for a ship-launched interceptor for Overland Cruise Missile Defense concept.

4. SM-2 Block IIIC leverages prior investments made in the SM-6 Block I and Evolved Sea Sparrow Missile Block 2 missiles.

5. In addition to the shipborne Aegis BMD system, the SM-3 Block IB interceptor also serves as the primary interceptor for the Aegis Ashore site completed in Romania.

6. As well as US and Japanese Aegis BMD ships, the SM-3 Block IIA interceptor will equip the Aegis Ashore site being built in Poland. SM-3 Block IIA will also be introduced to the existing Aegis Ashore site in Romania, and was planned for the two new Aegis Ashore sites in Japan that have recently been cancelled.

4.4 TECHNOLOGICAL REVIEW

DISTRIBUTED MARITIME OPERATIONS

Implication and Challenge

Author:
Kevin Eyer

Distributed Maritime Operations – a concept under which technology is used to integrate the total warfighting potential of diverse, geographically-dispersed ships, submarines and aircraft into a war-winning weapon – is exerting a profound impact on current US Navy thinking. To grasp both the fundamental concept and the long-term implications of Distributed Maritime Operations (DMO), it is essential to consider the seminal thoughts and documents out of which the concept has grown. These serve not only to allow a more complete understanding of DMO but, perhaps more importantly, permit a grasp of the concept's fullest potential. Only then can one begin to comprehend the essential steps and issues that lie along the path to a full implementation of this new war-at-sea strategy.

The destroyer *Ralph Johnson* (DDG-114) takes station astern the aircraft carrier *Nimitz* (CVN-68) during carrier strike group (CSG) training in May 2020. The US Navy's long focus on the CSG construct is giving way to a new operational concept of Distributed Maritime Operations (DMO). *(US Navy)*

HISTORICAL BACKGROUND

The first significant step in reaching the current edge of DMO at which we stand began with the advent of a significant Soviet threat arising with the fielding of a major anti-ship cruise missile capability in the late 1950s. In response, the US Navy undertook two significant programmes: a shift in defensive primacy from guns to missiles, and the development of Tactical Digital Information Links (TADILs). Missiles provided the necessary speed, agility and reach to begin to counter these new threats kinetically, whilst TADILs allowed the sharing of each connected unit's radar picture among all other TADIL-capable ships in a local force. For the first time ships were knit together by more than flashing light, signal flag and radio communications, and a wider, more complete situational awareness of the battlespace could be created in all of the participating units (PUs).[1]

The second major event was the development of the Aegis Combat System (ACS), which began in the mid-1960s and came to fruition in the late

This view of the guided-missile cruiser *Little Rock* (CLG-4) – taken during a port visit to Malta in 1964 – provides a good view of her first-generation RIM-8 Talos missile launcher and complex radar and communications array. The development of missiles and tactical data links in the early years of the Cold War marks some of the first significant steps on the journey to DMO. *(Editor's Collection)*

1970s. With the development of the ACS, ships achieved a near-full integration of the disparate, elemental combat systems resident in those ships so configured. Everything in an Aegis ship's combat system arsenal was suddenly able to work together, synergistically and automatically.

The final step necessary in moving from non-integration at any level to full integration of a local force occurred with investment in Cooperative Engagement Capability (CEC) in the early 1990s. In a nutshell, CEC operates in a fundamentally different manner to classic data links. Unlike TADILs, which share only highly-processed symbology in a time-late and relatively low-granularity manner, CEC shares raw sensor data, directly off a sensor's buffers, unprocessed and with such speed and volume that it appears to each cooperating unit as if any CEC-netted sensor is an actual element of that unit's own combat management system (CMS). Before CEC, it did not matter if every other ship and aircraft in the local force saw the threat with their respective sensors. An Aegis ship could only engage that threat once its own radar detected it. With CEC, however, if another ship or aircraft detects a threat, any ship in the CEC network can potentially engage, because it appears to each ship's CMS that '*their* radar is *my* radar'.

Of equal significance, the way in which CEC works means that every unit's 'picture' of the local battlespace, generated in each, discrete CEC-equipped unit, is identical to the picture in every other CEC-equipped ship or aircraft. With CEC, an identical, real-time, fire-control quality picture of the surrounding battlespace is continuously resolved in every cooperating unit (CU). Much of the confu-

The introduction of the Aegis Combat System was a major development in CMS integration in individual ships, with subsequent investment in cooperative engagement capability essentially allowing all appropriately-equipped ships in a local force to behave as a single, integrated combat system. This picture of the Aegis-equipped cruiser B*unker Hill* (CG-52) and the Aegis-equipped destroyer *Barry* (DGG-52) was taken in the South China Sea during an April 2020 deployment. *(US Navy)*

The dual-mode AN/TPY-2 missile defence radar would form an integral part of the geographically distributed but technologically integrated network of sensors and weapons that is envisaged by the DMO concept. *(Raytheon Technologies)*

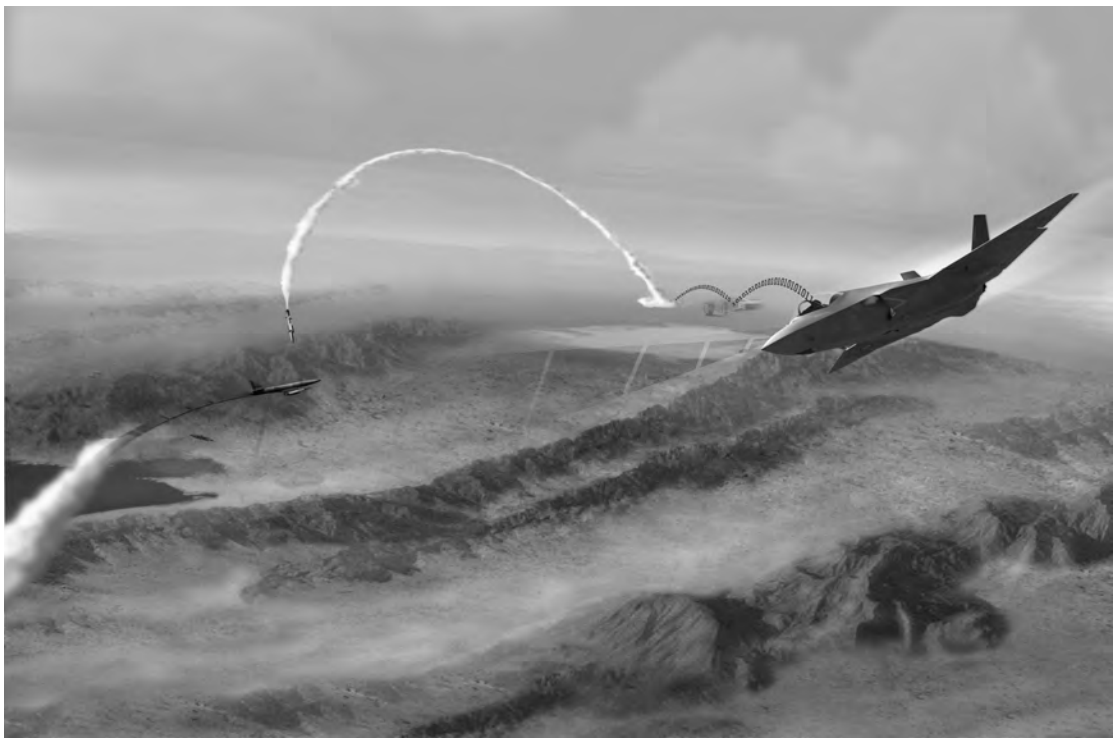
sion common in the past, when only TADILs were available, is eliminated. *You* see only and exactly what *I* see, and our picture is the combined outcome of the best sensor data of every unit in the force. Units can decisively act as one.

At last, not only were Aegis ships in a local force internally integrated into discrete, coherent wholes, but the entire local force was capable of behaving as a single, fully-integrated CMS.

THE DMO VISION

The potential of CEC was, however, much bigger. Rear Admiral Rodney P. Rempt, then Director of Theater Air and Missile Defense on the US Navy Staff, saw a more sophisticated future still.[2] In his view, the navy's tactical grid would be an agnostic network of weapons and sensors, controllable by any number of nodes, and without regard to where those weapons, sensors or controlling nodes might be deployed, or even in which unit, afloat or ashore, they existed. In the future, if an inbound threat was detected, this dispersed, integrated grid would determine which sensor(s) would be most appropriate, and then, pair the most capable and best-located weapon with that sensor(s) to efficiently engage the threat.

If, for example, a ballistic missile threat is detected by a given sensor, other sensors are immediately and automatically cued and brought to bear on the target. The operating mode of an in-theatre AN/TPY2 surveillance radar automatically changes to maximise its tracking capability.[3] A precise track, including origin and aim-point, is quickly developed. At the same time, commanders make decisions aided by the application of artificial intelligence. Is the threat real? What asset is under threat? What hard and soft-kill techniques and systems are best employed? What systems are in a position and possesses the capability and capacity necessary to engage the threat? What is the optimal engagement timeline? What additional sensors should be brought to bear and when? Is this a jamming, chaff or decoy-laden environment and, if so, what actions



This graphic of a trial of the Naval Integrated Fire Control-Counter Air (NIFC-CA) architecture provides an illustration of how a network of systems might be combined to provide the optimum response to a potential threat. Here, a F-35 strike fighter is shown sending targeting information on an over-the-horizon incoming missile to a land-based launch facility, from which a missile is fired to engage the target. *(Lockheed Martin)*

will mitigate this? What ordnance has the highest Probability of Kill (PK)? What firing doctrine is wanted? What electronic countermeasures should be employed, and where? What communications paths offer the most reliable and sustained connectivity?

It can be seen that, under this vision, automatic and specific orders are issued to the right units – whether they are surface, air or land-based – while the entire network, including other decision-makers, remains fully cognisant of the larger picture. Moreover, the system has built-in redundancies so that even if one node were to be destroyed, another automatically and seamlessly replaces it. All of these decisions can be automated, if desired, to maximise the speed of response. Ultimately, only the necessary and sufficient systems are matched to the threat, and at only the right time. There is no waste of limited resources, and there is no confusion.

This is, in effect, the long-term vision for DMO. In truth, the only difference between Rear Admiral Rempt's vision and a modern understanding of DMO are the systems and distances involved. Rempt's concept was constrained by line-of-sight limitations of CEC, which problematically remain to this day. In the future, DMO will be employed theatre-wide and a commander's ability to call upon widely-dispersed sensors and weapons from thousands of miles away in what is essentially real-time will need to be assured for the fullest potential of DMO to be realised.

Between the vision and its realisation lie many obstacles, both technological and organisational. Still, early, proto-progress has already been made in this direction. For example, Naval Integrated Fire Control-Counter Air (NIFC-CA), which is enabled by CEC, allows ships to engage air threats located far over the shooter's radar horizon. CEC also enables the 'engage-on-remote' capability that allows one unit to launch defensive missiles against a threat prior to detection of the threat with that ships own sensors. Moreover, in-flight retargeting allows dispersed units to contribute to an in-progress kill chain ensuring that the data remains as current as is possible.

Unfortunately for CEC and its remarkable promise for providing the connective tissue for a DMO vision, the US Navy's focus inexorably shifted towards power projection from sea to land following the Cold War's end as the world's 'blue water' threats disappeared. As a result, realisation of the vast potential of CEC went largely wanting as the strike mission assumed centre stage until Cold War type great power rivalry started to re-emerge.

THE MOTIVATION TO LEAP FORWARD

In January 2016, Admiral John M. Richardson, then Chief of Naval Operations (CNO) released his strategic guidance paper, *A Design for Maintaining Maritime Superiority.*[4] This paper discussed the necessity of returning to the larger strategy of sea control. Moreover, the document set the table for the US Navy's return to 'great power competition', sighting China and Russia as primary threats to United States and global interests. Perhaps most importantly, while DMO was not specifically mentioned, the CNO created a context in which DMO became the only solution to the dilemma the US Navy faced, 'We will not be able to "buy" our way out of the challenges that we face. The budget environment will force tough choices but must also inspire new thinking.' The implications of this phrase were, and are, of enormous significance.

In January 2017, Vice Admiral Thomas S Rowden, then Commander, Naval Surface Forces, responded to the challenge posed by the CNO's shift in strategy with his *Surface Force Strategy: Return to Sea Control.*[5] This document discussed an approach, called Distributed Lethality (DL), the gist of which was captured in the motto, 'If it floats, it fights.' DL was intended as an operational and organisational principle, ultimately designed to ensure that sea control would be reasserted and sustained despite a persistent decline in the fleet's overall size. DL was aimed to reinforce initiatives intended to drive collaboration and integration across warfighting domains; i.e., synergies that would produce a sum that would exceed the parts. More specifically, DL required an increase in the offensive and defensive capabilities and capacities of every class of surface ship.

The 2017 surface force strategy describes DL as having three tenets or components, viz.

1. Increase the offensive lethality of all warships: There is clear tension between the number of missions assigned to ships and the total number of ships available. Surface warships can no longer be

permanently tied to carrier strike groups (CSGs) and expeditionary strike groups (ESGs) whilst simultaneously achieving the geographical distribution necessary to put DMO into action. This suggests aircraft carriers and amphibious ships must be better prepared to defend themselves as escorts are peeled away whilst themselves also contributing to DL. This helps explain, for example, the aviation community's renewed interest in anti-shipping warfare and the enthusiasm for deploying F-35 strike fighters on amphibious assault ships. More widely, there is a need to 'up-gun' all platforms to allow them to punch above their weight class. The advent of new, offensive weapons systems will provide a key opportunity that can be leveraged through DMO.[6]

2. Distribute offensive capability geographically: This element of DL places an enemy at risk from multiple attack axes, forcing that enemy to defend an increased number of vulnerabilities. A disaggregation of forces is part and parcel of DMO. Long range strike weapons will provide the offensive punch currently lacking across the entire surface force and, by distributing them widely across different classes of geographically-dispersed ships, enemy forces will be held at risk in ways completely impossible today.

In 2018, the *Harry S. Truman* (CVN-75) CSG, demonstrated the new concept of 'Dynamic Force Employment' (DFE). The strike group was the first to venture north of the Arctic Circle in nearly three decades, spending significant time patrolling the Greenland-Iceland-United Kingdom (GIUK) Gap. Fundamentally, DFE deploys US Navy forces in a more diverse set of environments than those that have become common since the close of the Cold War. In the case of East Coast CSGs, these standard deployments have featured passages through the Mediterranean to launch air strikes on Middle East targets from either US Fifth Fleet or Sixth Fleet waters. According to the Admiral Richardson, '… we don't have to go too far back to sort of recapture what it means to be moving around the world as a strike group or an individual deployer and really kind of making everybody guess, hey where's this team going to show up next? What are they going to bring to us next?' In short, there are tremendous incentives to spread the available force but this will require making each unit more capable of operating independently and less predictably.

3. Give ships the right mix of resources to persist in a fight: This calls for an increase in defensive capabilities, not only against kinetic threats but also against cyber and electronic threats. Every ship must be a shooter, and every ship's sensors must contribute to the larger network. To do this, it is essential that ships are able to send and receive large amounts of timely and secure data, even when under cyber and electronic attack.

The wide distribution of offensive weapons systems throughout the US fleet is one of the preconditions for the effective implementation of DMO. The addition of a strike missile capability to the Littoral Combat Ships – this picture shows *Gabrielle Giffords* (LCS-10) in May 2020 with Kongsberg Naval Strike Missiles bolted to her forward deck – is reflective of this requirement. *(US Navy)*

In December 2018, the trio of recent US Navy strategic documents setting the scene for implementing the DMO vision was completed when Admiral Richardson released *A Design for Maintaining Maritime Superiority, Version 2.0*.[7] According to the then CNO, this update clearly aligned with both the latest National Security Strategy (NSS) released in December 2017 and the associated National Defense Strategy (NDS) of January 2018. It is plain that these documents orient US national security objectives firmly toward great power competition with China and Russia.

DMO made its first official public appearance in Version 2.0. The CNO called for the navy to, 'Continue to mature the Distributed Maritime Operations (DMO) concept and key supporting concepts; Design the Large Scale Exercise (LSE) 2020 to test the effectiveness of DMO. LSE 2020 must include a plan to incorporate feedback and advance concepts in follow-on wargames, experiments, and exercises, and demonstrate significant advances in subsequent LSE events.'[8] Further, the navy was tasked to, 'Design and implement a comprehensive operational architecture to support DMO. This architecture will provide accurate, timely, and analyzed information to units, warfighting groups and fleets. The architecture will include:

- A tactical grid to connect distributed nodes.

In 2018, the *Harry S. Truman* (CVN-75) CSG demonstrated the new concept of 'Dynamic Force Employment' by venturing into waters vacated by large US Navy warships since the end of the Cold War. Placing an enemy at risk from multiple attack axes, thereby forcing that enemy to defend an increased number of vulnerabilities, is an integral part of the DMO concept. This photograph shows a MH-60R helicopter from the carrier's air wing exercising with the Norwegian fast attack craft *Storm* in the course of this deployment. *(US Navy)*

- Data storage, processing power, and technology stacks at the nodes.
- An overarching data strategy.
- Analytic tools such as artificial intelligence/machine learning (AI/ML), and services that support fast, sound decisions.'

It is clear that the US Navy has finally recognised that DMO is the concept that will stitch together its up-gunned, widely-dispersed ships (and submarines and aircraft) into a coherent whole. The demands of sea control in an age of renewed great-power rivalry require a more capable fleet encapsulating new ways of thinking and fighting, including distribution. DMO is the leading edge of a long-term answer. Not only will DMO aid in the attack, but it will be critical in the defence. DMO will stretch an adversary's intelligence, surveillance and reconnaissance (ISR) capabilities as wider areas will have to be searched to find American forces. Perhaps more important, widely-dispersed forces will hurt an adversary's ability to concentrate fire on US forces as the enemy forces also must be more dispersed; albeit not linked in the same way that is possible with full realisation of DMO.

OBTAINING ENOUGH SHIPS TO DISTRIBUTE

Even if the desire to achieve DMO exists at all levels, a certain force level will be necessary to operationalise the concept. Will that force exist? Currently, the surface force has specific, numeric requirements for both large surface combatants (LSCs) and small surface combatants (SSCs). Whether these numbers are attainable is in some doubt. So too is the prognosis for the Littoral Combat Ship (LCS), which is now counted in the roster of SSCs. The chief obstacle which lies in the way of building more – and more capable – surface ships, is the US Navy's stated number one priority; building the *Columbia* (SSBN-826) class ballistic

DMO requires the deployment of significant numbers of ships to be effective but the US Navy is struggling to increase numbers. Here *Detroit* (LCS-7) – designated a small surface combatant – exercises with a large surface combatant, the destroyer *Gridley* (DDG-101) in January 2020. *(US Navy)*

missile submarines. The moniker 'number one priority' is not insignificant, as it means that if it is necessary to bleed other ship-building programmes in order to fund the *Columbia* class fully, then that is what will be done.

It is therefore understood that increasing surface force numbers will be challenging. At one time, it was hoped that the LCS would provide the necessary numbers of small, inexpensive surface combat ships to fill the gap. Unfortunately, this hope has been dashed as questions persist regarding class sustainability, survivability, reliability and offensive and defensive capability. A glimpse of the surface force's intention to address both raw ship numbers and DMO's operationalisation may have been displayed at the 2019 Surface Navy Symposium in Washington DC. The navy is seemingly arriving at the cusp of a true revolution in the shape of the surface force. In addition to the SSC and LSC types, which may be thought of as 'classic' warships, the surface force intends to embark upon the construction of an entirely new universe of unmanned surface vessels (USVs), both large and medium in size. These ships, in addition to a new FFG(X) future frigate class, will add significantly to SSC numbers. It is these two remotely controllable, unmanned, inexpensive, 'attritable' USV platforms that may light the way to a dispersed force of weapons and sensors.[9] The large USV will essentially be a floating vertical launching system (VLS) whilst the medium USV will deploy interchangeable plug-and-play sensors.

Efforts are also underway to fill the holes in the surface force's 'classic' LSC and SSC roster. A new class – literally named the 'Large Surface Combatant' – is intended to augment and follow both the *Arleigh Burke* (DDG-51) destroyers and *Ticonderoga* (CG-47) class cruisers. While its exact nature remains uncertain, current discussion suggests it will feature a common integrated combat system inside a new, larger hull. The ship is necessary to DMO in that it is the only planned class with sufficient space and power to support, among other systems, the sort of large radars necessary to engage new threats, as well as contribute meaningfully to an enhanced DMO picture. However, construction has been deferred until, perhaps, 2028 or later. Then there is the next in the series of SSCs, the FFG(X) future frigate. On 30 April 2020 it was announced that a Fincantieri design based on the Italian variant of the FREMM multi-mission frigate had won the contract for the new ship. Moving away from problematic LCSs to FFG(X) will provide additional small, multi-mission ships with improved capability. However, while the FFG(X) will be dramatically more capable than the LCS, it is debatable whether it has sufficient margin or power to take it well into the future.

The US Navy is increasingly seeing unmanned surface vehicles as a means of bolstering overall numbers. This is a small Common Unmanned Surface Vessel, initially designed to conduct mine warfare and other missions as part of a Littoral Combat Ship's modular payload. However, medium and large USVs are being developed to deploy, respectively, sensors and missile loadouts. *(US Navy)*

ENSURING A PERSISTENT 'EYE IN THE SKY'

With distribution comes challenges. Not only in terms of connectivity but also in terms of the discrete elements in the tactical grid. Far from either shore-based assets or a carrier's resident air wing, one must ask how ships will be able to maintain a picture of the surrounding world beyond the range of their own radar. Any hostile ship more than 20 or so miles (32km) away may be undetectable. Not only does this create vulnerabilities for the single unit but it severely limits the ability of controlling nodes to fully grasp the battlespace. A larger, more complete understanding of the tactical grid is required.

Owing to a range of issues, even ships equipped with two helicopters cannot sustain around-the-clock air operations. The solution must therefore lie in greatly expanded capability and capacity in terms of ship-launched and recovered unmanned aerial vehicles (UAVs). UAVs will serve several primary needs in a DMO environment; as sensors, weapons carriers and communication assets. Small UAVs equipped with sensors can greatly expand the footprint of dispersed ships. And, if they have long duration, this footprint can be maintained around the clock. A good, early example of this type of UAV is the Boeing Insitu ScanEagle. ScanEagle carries a stabilised electro-optical and/or infrared camera in a lightweight inertial stabilised turret system and an integrated communications system with a range of over 60 miles (100km); it also has a flight endurance of over 20 hours. Subsequently, improvements to the original design added the ability to carry synthetic aperture radar (SAR) and improved navigation systems.

These UAVs can extend the attack reach of widely dispersed units. Today, the MQ-8B Fire Scout is capable of carrying Hellfire missiles, Viper Strike laser-guided glide weapons, and pods carrying the Advanced Precision Kill Weapon System (APKWS), a laser-guided 70mm (2.75in) folding-fin rocket. Depending upon the size of the

Small unmanned aerial vehicles – here a Boeing Insitu RQ-21 Blackjack pictured in the course of launch from the flight deck of the amphibious transport dock *John P. Murtha* (LPD-26) in July 2019 – offer the prospect of expanding the surveillance footprint of dispersed ships, thereby improving understanding of the DMO tactical 'grid'. (*US Marine Corps)*

A MQ-8B Fire Scout UAV operating from the deck of the Littoral Combat Ship *Gabrielle Giffords* (LCS-10) in May 2020. Capable of carrying a range of weapons, such vehicles play a significant part in implementing the DMO concept. *(US Navy)*

flight deck, the variety and capability of UAVs seem limited only by the imagination.

Then there is the matter of communications relay, without which the 'distributed' part of DMO ceases to exist. As it stands today, navy communications face a number of vulnerabilities, not the least of which is a reliance on commercial satellite channels. By lowering the connectivity grid from satellite level to long-endurance UAVs, the grid gains a redundancy which could make the difference between fighting the next war 'in the dark' and fully realising the potential of DMO.

THE BRAIN OF DMO

To be fully realised, it is essential that DMO has command nodes which are able to control the widely-dispersed elements of the battle force. All of these units must be stitched together by a battle force manager (BFM) resident in the many and

The combat information centre on board the Aegis-equipped cruiser *Vella Gulf* (CG-72). For DMO to work effectively, it will require an equally capable battle force manager (BFM) scaled to meet the demands of an entire force. As of today, no such BFM exists. *(US Navy)*

varied nodes. For security purposes, this capability may be fully implemented in some nodes but only operationalised in others as required. However, more than one unit will need to have full capability in order to guarantee the reliability and flexibility of the overall architecture.

The US Navy is currently moving towards what is known as a Common Combat Management System (Common CMS). This is designed to replace all existing combat management systems, including Aegis CMS and the Ship Self Defense System (SSDS). It will be more efficient, more flexible, more easily updatable and less expensive. Having said that, the Common CMS should not be confused with a BFM. The Common CMS is strictly a local CMS. A BFM should be thought of as the CMS for the entire force, connecting all subordinated combat management systems together into a coherent whole. The BFM is the brain on top which connects all the brains underneath, whether they are in ships, submarines, aircraft or land-based assets.

The primary requirement of a BFM is the ability to ensure the composition of a single, commonly held and fully integrated picture of the battlespace, encompassing air, surface and subsurface domains, from the sea-bed to space; a true cross-domain picture. Every node in the grid must possess a real-time, fire-control quality picture, whether at the tactical or operational level, and this picture must be identical in every way to every other unit's picture. Without this single, integrated, real-time, fire-control quality picture, confidence is diminished and subordinate systems are dramatically sub-optimised.

This picture of the battlespace does not currently exist. Despite the much touted 'common operations picture', this view is not yet sufficiently precise to be tactically useful. One is reminded of a more powerful TADIL picture from the past. It may be useful at the operational-level of warfare in that it provides broad, situational awareness but it is insufficient to meet the challenges inherent to DMO.

A truly effective BFM requires the following elements:

- It will monitor connectivity with every unit on every circuit, automatically correcting problems without operator intervention.
- It will 'know' – in detail – the nature of all ordnance and the weapons posture of every unit in the force.
- It will be able to change the operational parameters of sensors and weapons systems, grid-wide.
- It will know each unit's mission, priority, survivability and condition, e.g. with regard to fuel and damage.
- It will understand which sensor/weapon combinations are best to deal with any threat and automatically issue commands to cause those weapons and sensors, no matter where they are located, to work seamlessly together. This will include both hard and soft-kill systems.
- It will know the operational limits of each node, including the weapons/sensor capability and capacity of each node, either manned or unmanned.
- It will be able to access and sort enormous amounts of data while simultaneously aiding decision making by channelling only the most salient and accurate prompts to the command team.
- It will include aspects of Artificial Intelligence (AI) to ensure decision-makers are presented only with information which aids decisions, holding other data in check unless called for. Moreover, this AI will be the necessary 'brain power' that enables all the other elements of the BFM and, by extension, DMO.

The guided-missile destroyer *James E. Williams* (DDG-95), front, and the guided-missile cruiser *San Jacinto* (CG-56), back, conduct replenishment-at-sea with the fleet-replenishment oiler *Laramie* (T-AO-203) in the Mediterranean in March 2020. A shortage of replenishment vessels is one of the Achilles heels of implementing DMO. *(US Navy)*

Needless to say, this BFM does not exist today, even in a proto form. Without it, DMO can only be a sub-optimised shadow of what it could be.

Just as important as the BFM is the development of a network which possesses the speed, capacity and security currently available only in the short-range CEC system. As is the case with a BFM, no such network exists, today. Satellite networks that allow the necessary range fail the bandwidth test; the amount of data required to fully realise DMO is far too great for satellites to support today. It appears that the US Navy's current solution is to cobble together various networks, some of which use satellites. It is possible that this might provide a stopgap but the question must be asked whether enough can be done with existing systems. For example, imagine a LUSV armed with a long-range surface-to-surface missile operating remotely. Can targeting data and

The Japanese JMDF destroyer *Myoko* (DDG-175) peels away from the carrier *Ronald Reagan* (CVN-76) in the course of exercises in the Philippine Sea in August 2019. DMO may require the disaggregation of the previously sacrosanct carrier strike group to facilitate a flexible response to emerging threats. *(US Navy)*

launch commands be delivered with the necessary granularity and speed, across potentially thousands of miles, in time for a successful engagement using today's communications networks?

TWO OTHER ACHILLES HEELS

In addition to these issues, there are two other vulnerabilities that require urgent address. One is the US Navy's vulnerability in waging the sort of warfare that has been planned and worked towards for decades. Today, it is increasingly understood that electronic warfare (EW) is becoming a sort of sand-based foundation upon which the entire edifice of US Navy warfighting capability shakily stands. In this case, EW should be thought of as the effort by which an unfettered and complete access to the entire electromagnetic spectrum (ES) is ensured, rather than from the small, tactical perspective of electronic attack, warfare support and protection.

Curiously, this situation has presented itself primarily as the unintended outfall of the US Navy's focus upon an explosive growth in C5I (command, control, communications, computing, combat systems and intelligence) capability. Over time, the navy has developed a remarkable and unique ability to fuse a widely-dispersed force together into a coherent whole, even if it falls short of that required to implement effective DMO. Unfortunately, any sensible adversary will recognise the advantage conferred by an undisturbed access to the ES, making this access a primary point of attack by any enemy possessing the means to do so. So, while it may be desirable to plan to employ this awesome capability, it also seems plain that in any real fight, full employment will be problematic.

There also is an overwhelming need to address the size of the US Navy's combat logistic force (CLF). This is particularly the case with regard to oilers. A combat ship refuels, in general, once every three days but this can be stretched provided that increased risk is taken as far as available fuel is concerned. As it currently stands the number of replenishment ships available is a problem, even in a non-distributed environment. The days of the US Navy possessing sufficient numbers of oilers so that one could be attached to each CSG are long gone.

What will happen as the fleet is broadly dispersed? From where will the fuel come? Perhaps more worrisome, how can stealth be expected to be maintained when it must be clear to anyone who cares to look that oilers will be forced to travel directly from one rendezvous to another. Track the oiler and find the targets. Or simply destroy the few oilers and achieve an effective mission kill on an entire force. Oilers

may not be 'sexy' but they remain the critical enabler in distributing the force.

PROTO DMO

In early 2018, Admiral Scott Swift, then Commander of the US Pacific Fleet, wrote a series of articles published in the US Naval Institute's journal *Proceedings* that offer a good insight into the possible Concept of Operations (CONOPS) that will be rendered possible by DMO. He describes a tactical grid, overseen by an operational (fleet level) maritime operations centre (MOC) that is charged by a joint forces command (JFC) to implement various 'effects' in different campaigns – for example logistic, anti-submarine, amphibious – across time and space to achieve strategic goals.

This CONOPS moves the conduct of warfare to a higher level than that achievable under the long-standing primacy of the unitary carrier strike group. Further, in order to successfully carry out these campaign effects, it may be necessary to disaggregate the once-sacrosanct CSG. For example, a threat submarine is detected in the vicinity of a key logistics asset. The fleet-level MOC responsible for the conduct of the maritime fight tasks the subordinate theatre anti-submarine warfare commander to destroy the threat. To execute this task, the commander may have to draw a destroyer from a CSG, not only owing to proximity but to bring that ship's sensors and weapons to bear. Once the threat is passed, the destroyer returns to the CSG. In short, a general paucity of assets in any high-end fight can only be addressed by the precise application of exactly the right amount of force, at exactly the right time and place.

While Swift did not specifically refer to DMO, it seems plain that the full realisation of his CONOPS will depend upon widely-dispersed forces that can react flexibly and quickly across the widest of areas. Neither does Swift consider the arrival and potential of USVs. These ships will be the first platforms that will allow formation of an actual proto DMO grid. LUSVs will free manned surface combatants for more complex, multi-mission taskings whilst MUSVs will fill persistent sensor gaps. For example, a LUSV carrying a mixed load of surface-to-surface missiles and SM-3 interceptors working in concert with dispersed radars would be able to conduct significant anti-surface and ballistic missile defence missions under the control of remote commanders. It could remain passive and undetected until needed and then, after use, be sailed remotely to a new, safe point to await its next command. Low cost but high contribution, USVs are intended to operationalise DMO.

Past and Future: The *Sea Hunter* autonomous USV demonstrator pictured against a backdrop of the battleship *Missouri* (BB-63) at Pearl Harbor in October 2018. USVs will be the platforms that will allow an actual proto DMO grid's formation, releasing manned vessels for more complex tasks. *(US Navy)*

What Admiral Swift did grasp was the conflict between a maturing, global CMS and the possible loss of the US Navy's unfettered use of the electromagnetic spectrum. The 2017 publication of his 'Fighting Orders' talked specifically to this issue. While their content is classified, the shape of these orders can be guessed at and they offer answers to some of the questions which would arise in an ES-denied scenario. Most significantly, the fleet is taking a new and unprecedented approach to what are known as 'Commander's Intentions'. These are the top-level daily directions published, typically nightly, by a local commander. In an age of instant communications within a local force, these Intentions had become pro-forma, vague and repetitive to the point of unreadability. However, this is changing. In between flashes of the brilliant clarity provided by DMO, future commanders might have to figure it out completely on their own. Admiral Swift put his finger on the button: everyone must have a deep and clear understanding of what their leader's plan is and how it might change, so, in the event of complete loss of communications, everyone will know exactly what to do.

DMO is the long-term goal of the US Navy. However, to presume that a thoughtful enemy will not bend every effort to strike at the ES base, upon which DMO must be built, would be folly. The secure and reliable communications fundamental to a MOC directing a LUSV to fire a SM-3 in defence of an aircraft carrier or city must be the navy's single, greatest concern. The US Navy may learn to fight 'in the dark' when and if necessary but it will lose all of its technological advantage if reduced to the same level as every other hostile force in the world.

IN THE LONG RUN ...

In the course of 'operationalising' a viable DMO system, a voyage of discovery will be necessary. What is essential first, however, is gaining a clear understanding of what DMO will do, so that a path to solving the many challenges inherent in its implementation can then begin to be described.

It is plain that there are many bridges to cross for the US Navy to achieve full realisation of DMO. First, it is not evident that anyone yet possesses a full grasp of DMO's potential, let alone an ability to describe a viable route by which to achieve it. Instead, fumbling attempts at gaining an understanding – often involving agencies with competing, parochial views – is beginning to take place.

Consider the new large surface combatant. Whilst all agree it must be built with the margin and power necessary for future systems, a discussion regarding how it fits into a DMO universe has seemingly yet to be undertaken. Similarly, there is little discussion regarding either a BFM, a new communications path, or the comprehensive defence of access to the ES. In any event, all of these discussions – even if they are wanted – will take place in disjointed, competing navy offices.

Moreover, there are any number of sacred cows and vested interests – ranging from aircraft carrier size through the appropriate role of unmanned vehicles to established command structures – that could stand in the way of progress. All these must be settled with an eye to achieving a viable and efficient future strategy. At the end of the day, what may be necessary in order to get 'there' from 'here' is a sort of modern-day 'Manhattan Project' incorporating all relevant interests possessing either a stake in the problem or a critical capability. Otherwise, one can expect a suitable, capable system to only arrive over a long timeframe and in sub-optimal fits and starts.

Implementing DMO correctly will mean that the US Navy will maintain a command of the seas for decades to come. Failure will allow its adversaries steadily to erode the advantages it has accrued over decades.

Aegis-equipped *Arleigh Burke* (DDG-51) class destroyers of DESRON 23 are headed by *Russell* (DDG-59) as they transit the Pacific Ocean in January 2020. Implementing DMO correctly will mean that the US Navy will maintain its command of the seas in the region for decades to come in spite of China's maritime rise. *(US Navy)*

Notes

1. For more information on the development of tactical data links see Norman Friedman, 'Modern Naval Communications', *Seaforth World Naval Review 2019* (Barnsley: Seaforth Publishing, 2018) pp.174–84.

2. Rodney Paul Rempt (born 1945) was closely associated with a number of air-defence programmes during his US Navy career, most notably the development of naval theatre ballistic missile defence (TBMD). He retired as a Vice Admiral in 2007 after a final assignment as Superintendent of the United States Naval Academy, Annapolis.

3. The AN/TPY-2 transportable radar surveillance system is a missile defence radar that can detect, classify and track ballistic missiles. It operates in two modes; forward based mode to detect missiles on launch and terminal mode to guide intercepting missiles onto target.

4. John M. Richardson, *A Design for Maintaining Maritime Superiority* (Washington DC: US Navy, 2016) currently available at: www.navy.mil/cno/docs/cno_stg.pdf.

5. Thomas S. Rowden, *Surface Force Strategy: Return to Sea Control* (Washington DC: US Navy 2017), currently available at: www.public.navy.mil/surfor/Documents/Surface_Forces_Strategy.pdf.

6. For example, see Dmitry Filipoff, 'How the Fleet forgot to Fight, Part 3: Tactics and Doctrine' posted to the *Center for International Maritime Security* website – cimsec.org – on 1 October 2018, 'The Navy's firepower is about to experience a serious transformation in only a few short years. Comparing firepower through a strike mile metric (warhead weight [pounds/1,000] x range in nautical miles x number of payloads equipped) reveals that putting LRASM [Long Range Anti-Ship Missile] into 15 percent of the surface fleet's launch cells will increase its anti-ship firepower almost twentyfold over what it has today with Harpoon. New anti-ship missiles will cause the submarine community and heavy bomber force to also experience historic transformations in offensive firepower. The widespread introduction of these new weapons will present the US Navy with one of the most important force development missions in its history. This dramatic increase in offensive firepower across such a broad swath of untapped force structure will put the Navy on the cusp of a sweeping revolution in tactics unlike anything seen since the birth of the aircraft carrier a century ago. How the Navy configures itself to unlock this opportunity could decide its success in a future war at sea. The Navy needs tacticians now more than ever.'

7. John M. Richardson, *A Design for Maintaining Maritime Superiority, Version 2.0* (Washington DC: US Navy, 2018) currently available at: www.navy.mil/navydata/people/cno/Richardson/Resource/Design_2.0.pdf.

8. In March 2020, the US Navy postponed LSE 2020 until 2021 owing to COVID-19 concerns.

9. An attritable design is one that trades performance characteristics for a lower acquisition cost, allowing more such systems to be acquired.

10. This chapter is derived from an article by the author and Steve McJessy entitled 'Operationalizing Distributed Maritime Operations' posted to the Center for International Maritime Security's *CIMSEC* site – www.cimsec.org – on 5 March 2019.

Contributors

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